ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Vol. XLVII. No. 17.

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THE LARGEST IMPULSE WATER WHEELS ever built, measured by the power developed, are to be made by the Abner Doble Co., of San Francisco, for the Bay Counties Power Co. of California. Two wheels are to be built to develop 3,700 HP. each, using water under a head of 1,600 ft. These wheels are to be direct-connected to 2,000 K-W. alternators made by the Stanley Mfg. Co., of Pittsfield, Mass., and both machines will be mounted on shafts of Bethlehem nickel steel.

CHANGES IN THE NEW CROTON DAM, in accordance with the report made last November by a commission of engineers, have been adopted by the Aqueduct Commission of New York city. The high earth dam, with masonry core wall, at the southeast end of the dam, will give place to an all-masonry section, in continuation of the main structure. Mr. Wm. R. Hill, M. Am. Soc. C. E., is Chief Engineer of the Aqueduct Commission.

THE MONTREAL, OTTAWA & GEORGIAN BAY canal project has been reported upon favorably by a committee of the Canadian Parliament. The estimated cost is $80,000,000 and time of completion 1910. As described in the report submitted by the committee, the surface water in Georgian Bay is about 564 ft. above the St. Lawrence at Montreal. It is proposed to raise the water in Lake Nipissing 66 ft. above Georgian Bay, making a total fall of 630 ft. from the summit level. The aggregate lift of all the locks will be about 650 ft. Three locks would be used to reach Lake Nipissing from the Bay, and the summit level will be 69 miles long, through a chain of connected lakes. From the east end of this level, to the junction of the Mattawa with the Ottawa, there will be a fall of 137 ft. and five locks in the 14½ miles. From the junction named to Fort William the fall is 145 ft. in 81 miles, requiring seven locks. From Fort William to the head of Lake des Chats, 56 miles, the fall is 115 ft., and five locks are required. To Lake Deschenes (47 miles) there is a fall of 55 ft.—and two locks, at the Chats falls; then, to the level river below Ottawa, there is a fall of 72 ft.—requiring four locks. In the Greenville canal there is a fall of 41 ft. and three locks; in the Carillon canal, 20 ft. and one lock; at St. Annes there will be a lock with a 3-ft. lift, and in the Lachine canal there is a fall of 45 ft., requiring three locks. The total distance from Georgian Bay to Montreal is 425 miles by this route, of which four miles will be taken up by locks, 40 miles will be canal, 22 ft. deep and 100 ft. wide on bottom; 74 miles will be in improved river channel, 300 ft. wide on bottom, and 307 miles will be in open lake and river suitable for 20-ft. navigation without further improvement. Mr. George Y. Wisner, M. Am. Soc. C. E., is the engineer making the report; and in this report he shows that the project simply restores old conditions—when the outlet of Lakes Superior, Michigan and Huron was by way of the route proposed to the valley of the Ottawa River. The canal would bring Lake Huron and Georgian Bay ports 400 miles nearer Montreal than by the St. Lawrence.

THE NEW YORK STATE WATER STORAGE COMmission, authorized by the last Legislature, has been named by Governor Odell, as follows: Prof. Olin H. Landreth, M. Am. Soc. C. E., Schenectady; John L. King, Syracuse; Elnathan Sweet, M. Am. Soc. C. E., Albany; Geo. W. Rafter, M. Am. Soc. C. E., Rochester, and Charles Finch, Glens Falls. In addition, the State Engineer, State Superintendent of Public Works, Attorney General and State Forest Commissioner are ex-officio members.

A WATER POWER COMPRESSED AIR PLANT is projected at Meramec Highlands, near St. Louis, Mo., by the Missouri & Meramec Power Co., of which Mr. R. D. O. Johnson is said to be Chief Civil Engineer. A canal 22½ miles long would convey water from the Missouri River to Meramec Highlands, between which and the Meramec River there is said to be a fall of about 50 ft. The capacity of the proposed canal is put at 5,000 cu. ft. per min.

ESTIMATES FOR WATER PURIFICATION and a meter system for Pittsburg, Pa., amount to $3,635,500, of which $2,981,000 is for the purification works and accessories and $654,500 for installing meters on all services. An award for the settling basins and filtration plant, alone, was made not long ago, but upset by the courts because the city charter prohibits contracts for a portion of an improvement until estimates for the total cost have been made.

SLOW SAND FILTRATION WORKS are reported as projected by the New Haven Water Co., of Connecticut, for a portion of its supply, and for the Indianapolis Water Co., of Indiana, the whole supply.

DAMAGES FOR WATER POLLUTION to the amount of $500 have been rendered against the Muncie Pulp Co. for discharging the wastes of its factory into Buck Creek. The verdict was rendered by a jury in a county court in the State of Indiana.

THE JOINT SEWAGE DISPOSAL WORKS for Birmingham, Ala., and vicinity, as recommended by Mr. Julian Kendrick, Chief Engineer of the Jefferson County Sanitary Commission, have been approved by Mr. S. M. Gray, M. Am. Soc. C. E., of Providence, R. I. Two independent joint outlet sewers are proposed, and it is recommended that experimental septic tanks and contact filter beds be installed on a working scale.

THE LOWEST BID FOR GARBAGE DISPOSAL for Brooklyn Borough, Greater New York, on April 16, was $47,990 a year, from the New York Sanitary Utilization Co., which holds the contract for Manhattan Borough and owns the reduction plant at Barren Island. The Brooklyn contract is to be for five years.

THE CONTRACT FOR GARBAGE COLLECTION and disposal at Baltimore, Md., has been awarded to Mr. F. W. Reidner, of Baltimore, at $147,300 a year for a term of ten years.

BIDS FOR THE LIGHT REFUSE CREMATORY for New York city, described in our issue of April 17, will be received on May 9, as stated in our advertising columns.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the wreck of a through freight train on the Louisville & Nashville R. R., near Riverside, Ky., on April 17. One man was killed and another fatally injured. The cause of the wreck is not known.——On April 20 a passenger train on the Pittsburg, Youngstown & Ashtabula Division of the Pennsylvania Lines West of Pittsburg ran into a work train near Newcastle, Pa.; the engineer of the passenger train was killed.

AN OHIO RIVER STEAMER BURNED on the early morning of April 20, resulting in the death of about 50 persons. The steamer was the "City of Pittsburg," bound for Memphis from Cincinnati. She had left the latter place on the night of April 16; when within a few miles of Cairo, Ill., the boat was found to be on fire, and it soon burned to the water's edge. Most of those on board were asleep when the fire was discovered, and this fact accounts for the great loss of life.

THE TONE CANAL-TOWING SYSTEM, invented by Mr. Joseph C. Tone, of Rochester, N. Y., is to be tried on the Erie Canal by the New York & Western Transportation Co., now operating the patent. This is a chain system of propulsion; the heavy steel chain lying on the bottom of the canal being taken up by a system of cog-wheels on the power-boat which is provided with boiler and engine for this purpose. This power-boat can tow a fleet of 25 ordinary boats at a speed of 3 or 4 miles per hour. This system is similar to that used for years past on the Rhine and other Continental rivers.

COUNTY ENGINEERS may be appointed in the state of New York under provision of a law just enacted. They are to be elected by the county board of supervisors, and their term of office is to be three years; but they may be removed at any time. They are to have oversight of highway construction and repair, giving instructions to the town highway commissioners, are to supervise the letting of contracts and must examine all highway bridges at least once each year. While the appointment of such engineers is not mandatory, counties which appoint such engineers and in addition vote to collect highway taxes in money, receive 50 cts. from the state treasury for each dollar raised by taxation for highway improvements.

INSPECTORS OF PAVING, with a technical knowledge of engineering, are wanted in Brooklyn, according to the expressed intention of Public Works Commissioner Redfield and Chief Engineer Tillson. This work has been heretofore performed by "practical" men appointed from the ordinary eligible list. Chief Engineer Tillson, who is a graduate of Rensselaer Institute, is in favor of having engineering graduates do this work. The present salary is $1,200 per year, but it is proposed to make it $1,500 for qualified men. The old employees are much dissatisfied with the proposed innovation; and promise failure as the result of submitting this work to inexperienced men, even if they are engineering graduates.

THE TOPOGRAPHIC MAPPING OF STATES, by cooperation between the States and the U. S. Geological Survey, says Director Chas. D. Walcott in his last report, has resulted so successfully that over 100,000 sq. miles of detailed mapping have now been completed, under this system, in 19 states, mostly on the Atlantic seaboard. Cooperation in hydrographic work has been invited, and work of this character has been carried out in New York, Pennsylvania, Maine, North Carolina, North Dakota, Colorado, Nevada, Arizona and California. As a result much valuable information is being gathered relating to water supply, irrigation and the development of hydraulic power. Several states have also obtained co-operation in strictly geological work.

THE TOPOGRAPHIC SURVEY OF OHIO, commenced in March, 1901, by the State and U. S. Geological Survey, now covers 4,310 sq. miles, or the larger part of ten counties. These maps will be issued in sheets about 16½ by 20 ins., drawn on a scale of about 1 mile to 1 inch, and the work will progress as fast as annual appropriations can be secured by the State.

A CO-OPERATIVE SURVEY OF MARYLAND has been arranged between the Director of the U. S. Geological Survey and State Geologist Wm. B. Clark. This is a resumption of work carried on some time ago in a similar manner. The map of Wicomico county is to be completed, preliminary work on Baltimore county commenced, and the map of Harford county—made two years ago in co-operation with the United States—is to be published.

SCHOLARSHIPS IN STEAM ENGINEERING and boiler and sheet metal work have been offered by J. T. Ryerson & Son, of Chicago, to the total value of $1,500 per year. The intention of the founders is to make the money available for educational purposes "alike to the ambitious rivet boy to the journeyman who would rise from the ranks, or even to that son who would succeed his well-to-do father." Details of the foundation have not yet been determined.

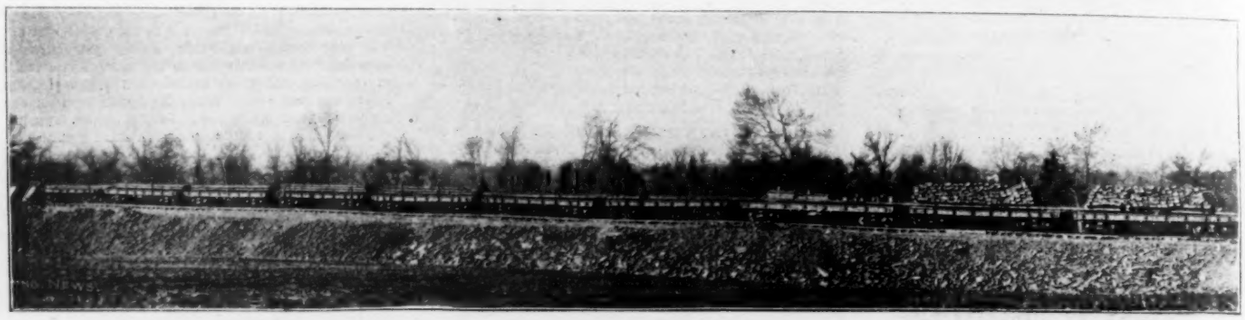
AN ENGINEERING SCHOOL, equal to the best of the technical schools of the country, is to be added to the regular schools at the Naval Academy at Annapolis; an appropriation of $400,000 for this purpose has been recommended by the Naval Committee, and this is exclusive of the $8,000,000 appropriated for new buildings, etc. Rear Admiral Geo. W. Melville is entitled to the credit for promoting this scheme for giving naval officers a thorough engineering education.

300,000 TONS OF PIG IRON, valued at $4,900,000, was bought by the U. S. Steel Corporation, on April 3, from the Bessemer Furnace Association. The price paid was $16.50 per ton, and delivery is to commence in October and extend to March, 1903. The U. S. Steel Corporation itself makes over 60% of the pig-iron output of the United States, or about 9,000,000 tons; but including the above sale the corporation has bought over 1,000,000 tons this year.

THE HURLEY TRACK-LAYING MACHINE.

By L. A. Wells.*

The Hurley track-laying machine, of which the accompanying illustrations give a good idea, is a new invention made by Mr. R. E. Hurley, of Scranton, Pa. It is being used for the first time on a new piece of track under construction for the Bessemer & Lake Erie R. R., near Greenville, Pa. The track is being laid with 100-lb. steel rails, and heavy oak ties, which have been handled with such success that the machine will quickly take its place as the most economical and rapid track layer ever invented.



THE HURLEY TRACKLAYING MACHINE AT WORK LAYING TRACK ON

As will be seen in illustration No. 1, the machine-car, in front of the construction train, from which power is applied to its three supporting trucks, has a steel truss-derrick, or crane, extending 60 ft. over the road bed, leaving a clear height below it of about 8 ft. Following the machine-car is a car with elevated platform, upon which the boiler, fuel, and water supplies are carried. The machine, together with its entire construction train of 16 cars of ties, rails, etc., are hauled by the machine-car as motive power.

The train is made up with the cars upon which the rails and track fastenings are loaded in the rear. Then come the tie cars and at the head the boiler and machine-cars. At the center of the length of each of the rail and tie cars, and about a foot from each side, is placed a roller, and on these rollers two lines of rails, one on each side of the car, are carried forward toward the head of the train. The power to haul the rails ahead is furnished by a cluster of friction rolls in the machine-car. At the rear of this line of rails a gang connects rail after rail as the line moves ahead, securing them by placing the angle bars on the rails and putting one bolt in both ends of each rail. When the rail arrives at the machine-car it is disconnected from those in the rear by taking out one bolt and slackening the other, leaving the angle bar on the rear end of each rail as it is sent out into the derrick, by power rolls, to a point about 20 ft. in advance of the machine-car wheels. Here it is grasped by specially constructed hoisting tongs and lowered by one man to the ties below. As the train moves slowly forward at a rate of 20 or 30 ft. per minute, the suspended rail reaches a point about 1 ft. back of the previously laid rail, from whence it is moved forward by hand, the loose angle bars passing over the ball of the stationary rail, when a clamp is placed over them. The rail is then released from the tongs, and the bolting is done while the train moves slowly forward. The possibility of making these connections "on the fly" is one of the most important features of the machine, and accounts, in part, for its rapid work.

The cars of ties are placed between the machine-car and the cars of rails, being so loaded that they give proper clearance for the rails, as they move forward over the cars, to pass under the ends of the ties. The rails are thus used as tie conveyors in the movement from the rail cars to the machine-car, as many ties being placed on each rail length as are required to be placed under it. In this manner they are carried forward to the machine, where they are taken from the rails by an attachment on an endless chain, and conveyed over the top of the derrick, which delivers them on the road bed about 12 ft. in advance of the outward end of the rail. The road bed under the derrick is thus kept constantly supplied with ties sufficiently in advance of the rails to allow time for proper adjustment.

The machinery is so geared that the material moves over the cars at exactly the same speed as the train moves over the track, thus keeping up a constant supply of ties and rails at just the rate required. This work is all done with the least possible amount of labor, and with very little lifting. The men are distributed over the train, and on the road bed in front of the machine car, in such a manner as to be free to work without interfering with each other.

The derrick in front of the machine car is at such a height as to give free action to the spikers below, and the front portion of it is so constructed that it can be swung to either side to suit the curvature, thus landing the ties exactly on the line.

Special appliances in the shape of tools are also used with the machine, making it possible to work with a rapidity that would seem at first to be quite out of the question. Those interested in this branch of railroading will appreciate the large economy resulting from the fact that this machine, with 40 men, is capable of laying two miles of track per day.

*Greenville, Pa.

THE PAINTING AND SAND-BLAST CLEANING OF STEEL BRIDGES AND VIADUCTS.*

By George W. Lilly,† Assoc. M. Am. Soc. C. E.

A moderately good paint, applied directly to the clean surface of the metal, under otherwise good conditions, will afford better protection than the best paint spread upon a surface with rust, scale, grease, moisture or old disintegrating paint upon it.

It is not intended to convey the impression that the selection of the kind of paint to be used is a matter of small importance, and this, should receive careful consideration and be decided in the light of past experience. The only true test of a paint as a serviceable protection to steel is the exposure of such paint for a long period of time to the weather and other destructive influences which it must withstand in use. Laboratory tests of short duration are of comparatively little value.

A paint as now employed is composed of the pigment and the vehicle, the latter becoming the binder when it has hardened, or dried, as it is called. Each of these serves its purpose in producing a serviceable paint. It is incorrect to say that either the oil or the binder is the life of the paint, for both are required to produce a lasting coating, which will protect the metal which it covers from rust and corrosion for any considerable length of time. Good, refined linseed oil is almost universally recognized as the best available vehicle and binder for such coatings. This may be modified by saying that a varnish vehicle may be used, but this is made by combining linseed oil and certain varnish resins by heat and proper manipulation in mixing them and adding, when cooled, some spirits of turpentine to cause it to flow when applied with the brush.

Linseed oil, when first manufactured, carries in suspension considerable moisture and various vegetable foreign matters, called "foots," which settle out by standing; and the oil must be at least three months old before it is really fit to use, and no doubt oil still older is better. If linseed oil appears cloudy, it is a pretty sure indication that it is too new, and should not be used. Much of the linseed oil in the market is adulterated with fish oil, resins, resin oil and mineral oils, which do not naturally form a film, and some so-called linseed oil is said to [illegible] linseed oil in it. All such oils should be scrupulously avoided. Raw linseed oil is said to make a better [illegible] than boiled linseed oil, but it sets so slowly that in [illegible] locations, such as viaducts subject to the blast, smoke, steam from locomotives, its use is inadvisable, because it will be filled with cinders and otherwise seriously injured before it is dry. Boiled oil will make a serviceable paint unless too much drier has been mixed with it.

The pigment is used to fill the pores of the oil, and to cause it to harden, so that it will better resist abrasion and the imbedding of dirt and cinders in it. Another service performed by the pigment is the thickening of the film so as to give better protection. As a general proposition, it may be said that the finer the pigment is ground the nearer impervious to water and gases will the paint be. The pigment protects not only the metal beneath, but also the paint film itself. The quantity of pigment should be sufficient to effectually perform its intended office. Paints to be used on wood need an excess of oil to fill the pores of the wood, but this is not needed on iron. The proportion of the pigment to the oil should be such that each particle of pigment will be surrounded by a film of oil and be thus cemented together and to the metal it covers. This will not be secured if too much pigment be used, and, on the other hand, if too much oil be used the paint will be too porous.

The pigments most commonly used for anti-rust paints on steel may be classed under the names red lead, iron oxide, carbon and graphite. Each of these has its champions among men who have had considerable experience in the use of paints. Regarding pigments, there is a lack of agreement, such as exists regarding linseed oil being the best binder. This disagreement has arisen, no doubt, at least to a considerable extent, from the fact that the pigments used have often been adulterated and their good qualities thus rendered of no value. Besides this, the variable condition of the metal to which they were applied, as well as the lack of knowledge as to the other conditions under which they were applied, make it a difficult matter to decide which pigment gives the best protection. About three years ago the Osborne Engineering Co., of Cleveland, O., made careful observations of paints which they had spread carefully on clean steel plates, quite a large number being so treated and a variety of paints used; and these were exposed for 16 months to the weather and the smoke and gases from locomotives. Their conclusion was that "red lead, oxide of iron, carbon and graphite all give results which average about the same." The observations carefully made by others who have had experience with this kind of work tend to confirm this judgment, although there is still much lack of agreement regarding it.

Iron oxide is composed of the anhydrous sesquioxide and the hydrated sesquioxide of iron in various proportions, and various other ingredients are often mixed with them, sometimes clayey and other deleterious matters to the extent of 75% of the whole. The anhydrous oxide is the characteristic ingredient of this pigment, and little, if any, of the hydrated sesquioxide should be present. Moisture in a paint is about as bad as anything that we have to guard against, and this is what we have when the hydrated oxide is present. It is the characteristic portion of iron rust, but iron rust has a larger proportion of water, and in addition to this carbonic acid, carbonate of iron and usually, perhaps, several other iron compounds. As is well known, rust once formed acts as a carrier of oxygen and carbonic acid from the air and causes further corrosion of the metal. So it is believed the hydrated oxide acts, at least in a measure, and should not be used on iron. Brown and dark red colors indicate the anhydrous oxide, and are considered the best. The hydrated oxides are characterized by bright red, bright purple and maroon tints, and, being less durable for a paint on steel, should be avoided. Some of the ores which are ground for paint pigment contain a large percentage of clay and other earthy substances, and their grinding being easy and less expensive than purer ores, the profits to be derived are a great temptation to the paint manufacturer, who is likely to be looking out for the money there is in it. The manufacture of iron oxide is sometimes effected by the action

*A paper read before the Engineers' Club of Columbus, O., Feb. 1, 1902.

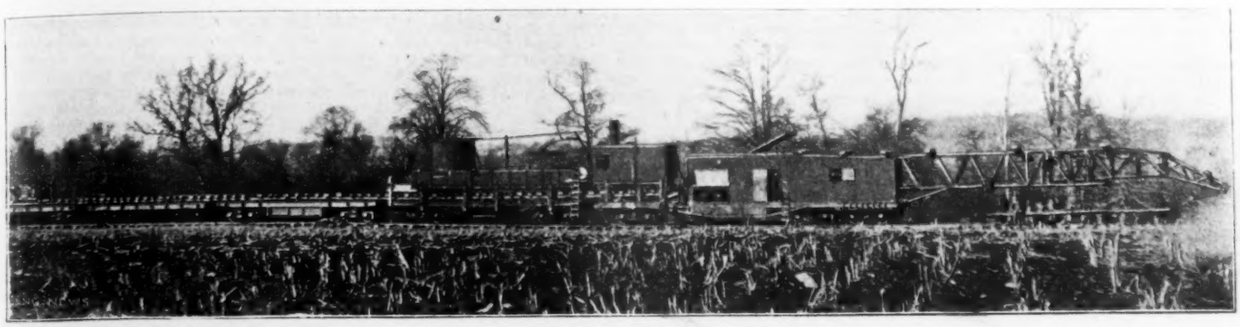
†Assistant City Engineer, Columbus, O.

sulphur compound upon iron, and it is then apt to con- sulphur, which will act upon iron in a degree like cases of coal combustion, and is not a desirable pig- for an anti-rust paint. It is likely that much of the sition to iron oxide for a paint on steel arises from fact that it has been so often adulterated. It must be itted, however, that some important bridges have been ed with iron oxide with good results. This would ate that when the best oxide is chosen a good paint be made from it.

Pure red lead as a pigment for painting steel has stood the test of time, and is now used to a large extent, especially as a priming paint for bridges. The United States Government uses it to a large extent on its various kinds of steel structures. This is usually a mixture of the peroxide PbO_2 and the protoxide PbO, although the peroxide is the characteristic ingredient, and the best practice seems to be to require that at least 90% of the pigment shall be the peroxide. It should also be free from admixture of whiting or other adulterants. Many think it easier to secure pure red lead than pure iron oxide for the reasons before mentioned. The superior hardness of red lead paint when dried and the firmness with which it adheres to the metal are important points in its favor for a priming coat on steel. If properly applied to clean metal, it will not shrink or crack, and will endure great extremes of temperature. These qualities make it a superior foundation for subsequent coats of paint. It has been objected to red lead that it is very difficult to get it properly applied, because it is difficult to spread it properly if mixed as thick as it should be, and that if not mixed quite thick it will run and not make a good coating. It is no doubt true that it is more difficult to spread than some other paints, and it is sometimes hard to get a contractor to do good work, because there is a great saving, both in cost of paint and labor, if he can mix the paint thinner and then dose it liberally with benzine to make it set or harden before it has time to run. But when intelligent care is taken with the mixing and application of red lead paint I have found it less difficult to spread than some of the best ready mixed anti-rust paints, and we mix the paint with 35 lbs. of red lead to 1 gallon of boiled linseed oil. Lampblack of good quality, not the cheap grades, may be used for the first as well as the succeeding coats, if on a bridge where it can dry without being injured by dirt, cinders or otherwise. The objection to it for viaducts and through railroad bridges while in use is its slow drying quality, and hence the necessity of using an injudicious quantity of driers to cause it to harden before it is filled with cinders from the locomotives, which will destroy the continuousness of the coat and introduce substances which will cause corrosion of the metal. The best carbon and graphite paints would seem, from some results on bridges which have been protected by these paints for many years, to have very good preservative and lasting qualities when applied as a first or priming coat, as well as for the subsequent coats.

When red lead is used for the priming coat, especially on viaducts over railroad tracks and other like exposed places, some other inert and otherwise good preservative paint should be used for the subsequent coats, as it is injuriously affected by the combustion gases from coal. The best carbon and graphite paints are no doubt good for this purpose. So also are some of the paints made from the best hard asphaltum, with varnish or linseed oil for a vehicle. The best informed engineers usually favor the application of two not too thick coats over the red lead. The object of using more than one coat of paint on any structure is not only to get a heavier body of paint, but, fully as important, to secure as nearly as possible a non-porous coating, the subsequent coat serving to fill the pores of the one previously applied. This is important, because a porous paint—and none have been found which are perfectly impermeable to moisture and gases—gives no lasting protection.

The use of turpentine, benzine and bisulphide of carbon as thinners or extenders of the paint should never be permitted. Benzine is so volatile that its rapid evaporation is said to so cool the metal that the moisture of the atmosphere is condensed upon the surface of the metal just in front of the brush, and the paint will not properly adhere and is also in danger of becoming blistered. The bisulphide is more injurious than benzine, on account of the presence of sulphur in it. All of these thinners, or rather extenders, of the oil cause the same amount of paint to spread over very much more surface and make the coat of paint excessively thin. They also make the paint brittle, and so shorten its life. Benzine and bisulphide of carbon, being much cheaper than turpentine, are more likely to be used by a contractor, and they are at the same time more injurious than turpentine, which is also undesirable.



THE BESSEMER & LAKE ERIE R. R., NEAR GREENVILLE, PA.

A CEMENT AND RED LEAD PROTECTION.

Nearly two years ago the P., C., C. & St. L. Ry. Co. applied to the steel bents and girders along the east side of the High St. viaduct, in this city, supporting its buildings and driveway over the railroad tracks, a coating composed of Portland cement and red lead and linseed oil. Portland cement alone not being well adapted to make a lasting protective coat, when so thin a covering is used, being too inelastic and liable to crack, some red lead and linseed oil were added to make it elastic. This was applied with trowels and made a coating about ⅛-in. thick. The steel had been cleaned by means of the sand blast and painted the season before, and only hand cleaning with steel brushes was needed. The cost of this coating, inclusive of the hand cleaning and all the materials, labor and other expenses of applying it, was 8 cts. per sq. ft. It now seems to have adhered well, even on the under side of the lower flanges of the plate girders, and the surface of the metal is found to be well protected and bright wherever the coating has been cut off for inspection. This is a very good showing after exposure for 22 months on some parts to the blast and combustion gases from a large number of locomotives passing every day into and away from the Union Station, the clearance being only about 24 ins. above the tops of the smokestacks. Whether it will remain good for years to come remains to be seen. At any rate, it is interesting to know that it has stood this very severe test so long as it has, and it may be that this will prove to be an effective protective coating, especially for the portion of important viaducts which is exposed to like severe tests, where the wear produced by locomotive blasts is in a large measure the cause of the early failure of paint coatings. The cost of such a coating would not be warranted under ordinary conditions, unless it shall in the future prove to be practically permanent, so obviating the necessity of recoating at frequent intervals, as must be done with paint.

MIXING AND APPLYING THE PAINT.

All paints should be very thoroughly mixed by machinery and subsequent grinding with a burr-stone mill if possible. But red lead, which is inclined to settle and harden somewhat in the mixture and make it difficult to spread and also diminish the coherence of the coating made by it, can be quite thoroughly mixed by hand where the facilities for machine mixing are not at hand; and this is advisable in most cases, for the reason that it is usually impossible to have it mixed at the time it is needed except it be done by hand. If the paint has a tendency to settle, it should be frequently stirred while being used from, and the buckets containing the paint should have only a small quantity of paint in them, so that the dipping of the brush will constantly aid in keeping it from settling. In using red lead paint, I have found that the spreading was made easier and the resulting coat of paint was better when a fresh batch was mixed each day, only enough being mixed each morning to last through the day; and in all cases the whole of one batch should be used or removed from the mixing tub before the next one is mixed, and no old paint be mixed with the new batch.

All paint should be thoroughly brushed out in applying it to the metal. In order to accomplish this, only the best round, full bristled and rather stiff brushes should be used. This is important, for the reason that air, with its attendant moisture and gases, clings to the surface of the steel, and unless the brush be used with considerable vigor and thoroughness this film of air and moisture will not be forced out from under the paint and will be imprisoned between the paint and the metal. The paint will then not adhere well, and the conditions be exceedingly favorable for the formation of blisters, and rusting will soon set in. Especial care is needed to insure the spreading of the paint on all parts of the surface, under the edges of the rivet heads and in all reentrant angles and over the edges of the different pieces, so as to give the metal a perfectly continuous coat of the paint.

If possible, all painting should be done when the temperature of the atmosphere is above 55° F., when little trouble will be experienced in spreading red lead or any other of the commonly used paints. If painting is done when the temperature is lower than this, the paint should be warmed by placing it in a vessel, which is set in water heated to a temperature of 130° to 150° F., and each painter should be frequently supplied with warm paint, as the paint he has in his bucket becomes cool. It is inadvisable to paint steel bridges in cold weather, but if it is necessary to do so, this method will secure very good results. During the latter part of November and the early part of December, 1901, a portion of the plate girder viaduct on Front St., over the L. M. R. R., in this city, was painted, the temperature averaging 37° F. All the paint was warmed, as suggested, and we had no particular difficulty in getting the men, who were hired by the day, to do a very good job of work, and the paint covered about one-third more surface than the same paint would have covered if not warmed. In this case red lead of the proportion to the oil before mentioned (35 lbs. to 1 gallon of oil) covered 400 sq. ft. to the gallon of paint. The same mixture in a former trial, when the temperature was about 40°, covered 290 sq. ft. to the gallon of paint. The former was sand-blast and the latter hand-cleaned surface. In another test, when the temperature was 60°, one gallon of this mixture covered 600 sq. ft. of surface of hand-cleaned steel. All of these tests were made on old viaducts being repainted and on steel in very similar condition, although the cleaning differed as stated. In the last two tests mentioned the paint was not warmed.

Paint which is applied when the metal surface is wet or during rainy or foggy weather, or when the metal is so cold as to cause the moisture of the atmosphere to condense upon its surface in a fine film, is not a serviceable coating. At such times one is apt to be deceived by the appearance of the metal surface, which may appear to be dry, but upon close examination be found to be covered with moisture sufficient to prevent the paint from adhering to the steel as it should to be of service. Contractors and painters working by the day do not like to suspend work at such times, and it requires a superintendent or inspector who will constantly observe the condition of the surface to be painted and insist upon the painting being discontinued at such times. The first coat of paint will never set properly if the second coat is applied while it is still soft. From three to four days should elapse between the application of one coat and the subsequent coat, and if it is possible to permit one week to elapse between them it is safer to do so. Some paints set or dry slowly, and even a longer time than this may be advisable with them.

CLEANING THE STEEL BEFORE PAINTING.

Before any paint or other coating of any kind is permitted to be applied to the iron or steel of a bridge or viaduct, all the scale, rust, dirt, grease and other foreign substances, as well as dead paint, should be removed from its surface, so that the coating may come into intimate contact with a clean surface of metal, and thus give the best condition for firm adhesion of the coating to the metal. No one who has had any experience with such work will dispute this proposition, and yet all over the country bridges are constantly being painted with very slight attempt to secure a clean surface for the paint. The cost of cleaning, and, in the case of new work, the delay in getting the material into the field for erection, are the cause of much of the poor work done in this matter. It has been suggested by some that for new work the metal be required to be cleaned and painted before it leaves the rolling mill, but this requires the steel to reach the shop several days later than it does when sent immediately. Some have even said it should be painted while still warm from the rolls, but the objection to this is that the scale always found on the steel after rolling would thus be covered with paint. The warm condition of the

steel would be favorable to securing good adhesion of the paint if the scale were not present. A better method would be to keep the steel under shelter until it has been machined and made ready to be assembled, and then, before riveting it, to clean it thoroughly and apply the first coat of paint. This would prevent centers of rust being afforded on the surfaces of contact. The machining loosens and removes much of the scale, and if the steel were housed and the shop work done soon after the metal is rolled, hand cleaning might be sufficient in many cases. But if rust has already formed to any considerable extent, some better means may be required to secure clean metal before the painting, and it has been suggested that rotary power driven steel brushes would be a good means of doing the work. Under present shop arrangements it would usually be impossible to have the steel housed or have the shop work done before rust has set in to a considerable extent, when the cleaning is a more difficult matter. In cases where good cleaning cannot be done by hand, perhaps in many cases the rotary steel brushes might do the work without much cost, but if these will not do so, the sand blast affords a method which can be relied upon to clean the steel so that there is absolutely nothing to prevent the paint adhering to it. The objection to its use is the cost of the work and more delay than is required with the past careless method of painting over scale and rust and more or less oil from the machines. But delay must be expected with any method of thorough and good painting, and the cost need not be very great if the bridge shops would fit up with permanent sand blast appliances and machinery.

The sand blast has been given sufficient trial to make it reasonable to say that such cleaning as is necessary on new work at the shops—that is, removal of mill scale and some rust and grease—can be done at about ½ ct. per sq. ft. of steel surface cleaned, and possibly a little less. This is reported to have been the cost of cleaning such steel plates at the United States navy yard at Brooklyn, N. Y., with a moderately perfect permanent plant. Hence it is reasonable to expect that with more experience and an improved permanent plant such work can without doubt be done at this cost or perhaps a little less. On the basis of ½ ct. per sq. ft., the cost per ton for cleaning steel plates would be: For plates 1 in. thick, 49 cts.; for plates ½-in. thick, 98 cts., and for plates ¼-in. thick, $1.96. For shapes: For 7-in. I-beams, weighing 17.5 lbs. per ft., the cost would be $1.35 per ton; 12-in. I-beams, weighing 50 lbs. per ft., would cost about 80 cts. per ton, while heavier sections would cost less and lighter sections more. The average cost for cleaning most plate girder bridges would probably be about $1 per ton. The cost for a truss bridge might vary from $1 per ton for heavy bridges to $1.75 per ton for light bridges. These figures are based on what has been done in only a few places, but upon actual work, and it may be reasonably expected that they are not too high.

Whenever such cleaning as this would effect shall be required of the bridge shops and paint of good, lasting, protective qualities shall be properly prepared and first coat applied to the metal so cleaned immediately after being cleaned, under proper conditions of weather or under shelter and dry, it will be possible to maintain our bridges without the necessity of again cleaning with the sand blast for a long period of time. It would be necessary to have such bridges inspected occasionally and when they need repainting, but before the paint shall be worn off, or so far destroyed as to seriously affect the metal beneath, a new coat of paint should be applied after a thorough cleaning with scrapers, wire brushes and other tools, such as may be required. We may not hope to see this accomplished before the purchasers of bridges shall require it, because the desire to make good profits will prevent the bridge manufacturing companies from adopting it. It is to be hoped that railroad companies, municipalities, counties and others requiring such structures to be erected will at no very distant day adopt such requirement.

Mr. L. L. Buck, Engineer for the New East River Bridge, specified sand blast cleaning for that structure, and the same should be done for all important bridges and viaducts. For such structures as are exposed to gases from the combustion of coal this is especially desirable. Of course, when this is done the additional cost must be paid, but it will no doubt be a saving because of the longer life of the paint, less frequent repainting and longer life of the structures.

The more serious question arises as to the structures heretofore erected, a large majority of which are being rapidly destroyed by rust and corrosion. The viaducts over railroad tracks are more affected than bridges in other locations, on account of the severe trial to which they are subjected. The same is true of trusses and all steel work of train sheds and shops, and to a somewhat less degree as to through railroad bridges. Many of such viaducts and other structures, after standing not to exceed eight or ten years, are found to be in a deplorable condition, although in many cases cleaned by hand and repainted from one to three times. Upon such structures scale will often be found as thick as the original metal, with distinct layers of paint and scale and in many cases with the paint still in fair condition upon the scale. The rust has worked under the paint perhaps as much as through it. For such structures the best hand cleaning is of little effect. After using scrapers, chisels and other kinds of edge tools, loosening scales as far as possible by jarring produced by blows of hammers, then thoroughly brushing with steel brushes, followed by whisk brooms or stiff bristle brushes, much rust and scale very closely adhering to the metal still remains, and very often when the first coat of paint is applied over this the scale will be loosened by the oil softening up the cementing rust.

The only way I know of to effectually clean such metal so that it will be in proper condition to receive the paint is by the use of the sand blast. By employing it every trace of rust and scale and old paint, grease and dirt can be removed and the true metallic surface of the metal exposed to receive the paint, which will then closely adhere to it and afford such protection as it is impossible to secure with the very best hand cleaning or in any other way. Trials of this method on such work have been made, but rarely on a large scale, and generally on a sort of experimental basis. The cleaning of about 50,000 sq. ft. of the 155th St. viaduct, in New York city, was very satisfactory, but the cost averaged about 13 cts. per sq. ft., with a minimum of 10 cts. on a portion of it. Old plates have been cleaned in the United States navy yard at a cost of 4 cts. per sq. ft. with a temporary, somewhat experimental plant. Later a more permanent plant was installed and undoubtedly such work is now done at less cost. The United States Government Army Engineers cleaned nearly 50,000 sq. ft. of steel lock gates and aqueduct on the Muscle Shoals Canal during 1898 and 1899. The plant was erected upon a boat, and seems to have been a fairly complete one. The total cost of cleaning and painting was 5.88 cts. per sq. ft. of surface, and probably the cost of cleaning alone was about 3 cts., or a little more or less, but it is not separately stated. The experience of the P., C., C. & St. L. Ry. Co. in cleaning steel under the High St. viaduct buildings and driveway at Columbus, and on a bridge at Akron, O., indicated that such work would cost about 3 cts., although no accurate record of surface cleaned and cost seems to have been kept.

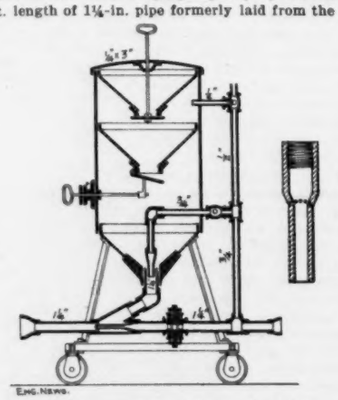
To secure good results, it was determined in the summer of 1901 to use the sand blast in cleaning some of the viaducts of Columbus, O., several of which urgently needed cleaning and repainting, some parts of them being so badly rusted as to be covered with thick scale and pitted to a considerable extent. Unavoidable delays prevented the commencement of the work until late in November. It was decided to make a beginning on one of the small viaducts, notwithstanding the unfavorable season of the year, and the Front St. viaduct over the L. M. R. R. was chosen as the one to be first cleaned and painted. This is composed of six quite heavy plate girders, with floor system of 9-in. I-beams and buckle plates, and having an exposed painting surface of a little less than 25,000 sq. ft. A 2-in. steel pipe line, 2,300 ft. long, was laid from the receiver of the air compressor at the east end of the Union Depot, and air was furnished by the Union Depot Co. at a charge of 40 cts. per hour for one sand blast machine and 60 cts. per hour for two machines. More than half of the time one machine was used, and the remainder of the time two machines and nozzles, one sand hose leading from each machine. The 2-in. pipe was somewhat increased in carrying capacity by the aid of a 1,300-ft. length of 1¼-in. pipe formerly laid from the compressor connected into the 2-in. pipe under the High St. viaduct. A small receiver of about 9½ cu. ft. capacity was placed at the viaduct to be cleaned and the pipe connected into it and then out of it to the machines. This dried the air better, and a considerable quantity of water was drawn out of it each day by a cock in the bottom, the amount varying with the moisture in the atmosphere. The sand blast machine used is the one invented by J. M. Newhouse, a general foreman of the P., C., C. & St. L. R. R. Co., at this place. It will be seen from the drawing that this machine has some features not seen in other machines. One of these is the arrangement of the air and sandpipes, with nozzle shaped air-siphon pieces in both the air and sand pipe, to facilitate the working of the machine without clogging. The nozzle leading the air through the opening in the bottom of the machine being surrounded with sand, and having small holes extending [illegible] out, the air escaping through them keeps the sa[illegible] up and prevents its clogging and also keeps [illegible] chamber filled with compressed air. Three valve[illegible] vided, two of which serve to regulate the relati[illegible] of air and sand so as to do the most effective w[illegible] the upper one, a 3-way cock, regulates the supply [illegible] pressed air to the upper section of the machine [illegible] mits the filling of the machine with sand without [illegible] the sand blast. These machines are placed up[illegible] castors to facilitate moving them about where [illegible] the air being led from the pipe to the machine by [illegible] rubber air hose 50 ft. long. The sand hose may [illegible] rubber hose 2¼ or 2½ ins. in diameter, sufficiently [illegible] to stand the pressure used, with a nozzle of ½-i[illegible] heavy gas pipe, which was used because it costs le[illegible] tool steel and not many more are required. Two [illegible] each day were worn out, the most severe wear being [illegible] from the reducer connection to the hose. We use [illegible] lengths of the pipe, because it was found that the [illegible] more effective than when a short nozzle is used, [illegible] permits the nozzle man to stand farther from the [illegible] being cleaned, and not be so much affected by sand [illegible] flying dust. The sand rebounds with sufficient fo[illegible] frost the glass of his helmet and require the gla[illegible] changed about three times each day. With this ma[illegible] it has been found that the blast is practically as eff[illegible] with 100 ft. as with 30 ft. of sand hose.

We usually used not more than about 30 to 35 [illegible] sand hose, for the reason that it is less expensive. [illegible] pressure at the entrance to the machines averaged 33 [illegible] ranging from 25 to 38 lbs., as shown by a gage empl[illegible] at all times, and a record of the pressure was made [illegible] day. The sand was dried in two old locomotive ash-pa[illegible] which were placed on brick walls high enough to give fire space, and it required the attendance of one man to dry enough sand to keep two machines running. The sand must be cool again before being used, to prevent steaming in and clogging of the machine, and a sand house was constructed to store a small quantity of dry sand.

This viaduct affords only sufficient clearance for the highest cabooses, and hence no scaffold could be swung from the floor I-beams. Above the clearance for lower side of the plate girders) it is only 12 ins. to the buckle plates. When working over the main tracks, on account of the curves in the tracks leading to the viaduct, three flagmen were required to watch for the trains and warn the workmen to clear the track. These were furnished by the railway company and paid for by the city. The interruption of work by trains amounted to 1½ hours per day, while working over the main tracks, or one-fifth of the working time during the short days of that time of the year; 12,600 sq. ft. of the viaduct were cleaned and then the weather became so severe that the work was discontinued on Dec. 13. The cost of the work, including flagmen, drying the sand, compressed air and all other expenses, was 3.04 cts. per sq. ft. The best day's work was 1,227 sq. ft. at a cost of 1.23 cts. per sq. ft. This was in a favorable location, accessible and uninterrupted by trains, and on the surface of a plate girder; 3,727 sq. ft. of such surface cost 2.37 cts. per sq. ft.

The red lead priming coat, of the mixture before mentioned, was applied as soon as possible after the cleaning was done, the painters following very closely after the nozzlemen, so that it required only one-half hour after the blast was discontinued for the day for the painters to complete the painting of the surface cleaned. No cleaned surface was left over night unpainted. Upon the surface thus secured the paint, warmed as suggested, seemed to make a good coating, firmly adhering to the metal, notwithstanding the unfavorable temperature at which the work was done.

With added experience, favorable weather and longer days, and such improvements in appliances as may be made, it is not unreasonable to expect that, where uninterrupted by trains, this kind of sand-blast cleaning can be done for less than 2¼ cts. per sq. ft., and it is hoped that we may be able to do that well on our viaducts where there is room for a staging, giving clearance sufficient for the passing trains. After once cleaning a bridge in this thorough manner and properly applying the paint, it is expected that it can afterward be maintained in good condition for a great number of years by proper care in inspecting it at frequent intervals and cleaning by hand and repainting whenever the paint shows sufficient wear to endanger the rusting of the steel. We hope to resume this work when the weather is favorable and continue it during the coming season. It is expected that better figures may then be shown than we have at present.



The Newhouse Sand Blast Machine Used in Cleaning Viaducts, at Columbus, Ohio.

In a personal letter the writer of the above paper informs us that the sand blast cleaning has been resumed this season, and it is expected to continue it for a considerable time.

In connection with the use of the sand blast for cleaning steel, we note the following in the March "Proceedings of the Central Railway Club":

Mr. Keil (Foreman Painter, L. S. & M. S. R. R., Buffalo.)—I believe I was the first man that took up the sand blast on locomotive work, about 16 years ago. It used to cost from $4 to $6 to prepare a new steel tender tank ready for

painting. After I perfected the sand blast the work could be done on a small steel tank for $1.25 and a large one would average from $1.50 to $1.75. I noticed after two or three years' service of these tanks that there was a great saving in the cost of repainting. The after results pay well for the time taken at first, but it is also cheaper in the first place. As to the pneumatic painting machine, in places where it is hard to get in with a brush the machine is certainly a good thing and the places that in my judgment would rust out the quickest are under the sills or places that are generally left untouched when painting is done with a brush. I believe that rust in the steel car is the same as a cancer in a person's body; it must be removed down to the bottom; if not, it will keep on. No matter how well painting is done, the rust must be removed first; otherwise it will rust under the paint. I used to be very careful in doing a steel locomotive tank. As soon as I was through sand blasting to have it painted at once. In one hour's time, with a powerful magnifying glass, the tank would show rust, no matter if it were a dry day. I found that it paid to put the paint on at once.

DRAFTING ROOM OF THE TOLEDO PLANT, AMERICAN BRIDGE CO.

By R. G. Manning, Assoc. M. Am. Soc. C. E.*

The drawing room of the Toledo Plant of the American Bridge Co., which was first occupied last May, is one of the most modern so far as light, equipment and pleasant surroundings are concerned. Situated on East Broadway at the crossing of the L. S. & M. S. Railway, in the eastern part of the city of Toledo, O., and almost to the city limits, it is practically free from smoke and noise, which are so common to most drafting rooms. There is a spacious lawn surrounding the office, and in the rear of the office are two tennis courts where the men play at noon and evenings. All the surroundings and equipment are such as to make a person content with his lot in life, and

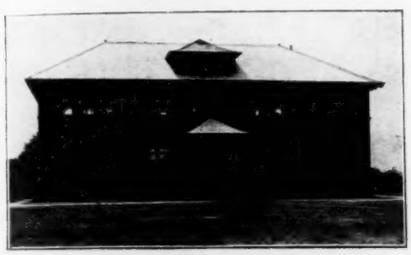


Fig. 1. Office Building and Drafting Room of Toledo Plant of the American Bridge Co.

to tend to promote a good feeling among the men.

Fig. 1 is a view of the office, the basement of which is divided into a bicycle room, dining hall, kitchen, furnace room and toilet rooms. The dining room wil seat 50 persons and dinner is served each day. The first floor is occupied by the general offices, including the inspectors' rooms. The second story is wholly devoted to drafting, and the third floors to blue printing and stores. Fig. 2 is a plan of the drafting room. The main features of this room are as follows:

Each desk, at a window, is provided with a locker and bookcase combined, so that each draftsman has a place for his clothes, books and miscellaneous articles, and keeps everything out of sight, leaving the room with a clean and neat appearance. Lockers for those tables down the center are provided along the stairway as shown by Fig. 2. The top sash of each window is fitted with factory ribbed glass, which gives a uniform light through the entire room, so that the tables in the center of the room are nearly as well lighted as the ones at the windows. The lower sash is fitted with plain glass so as not to obstruct the view. The projecting eaves of the building keep the direct rays of the sun from the room during the summer season, when the sun is high. The artificial light is provided by incandescent arc lights with inverted shades, throwing the light to the ceiling and reflecting it through the room in a mellow white light which is very easy on the eyes. Shadows are nearly done away with, and there is an absence of the network of fixtures common to the ordinary lighting by incandescent lights. One lamp should be provided for about every 12 or 14 ft. square of floor space.

*Engineer Toledo Plant, American Bridge Co., Toledo, O.

The stools of the drawing room are fitted on the legs with rubber tips which prevents a great deal of noise, especially to the offices below. There is a speaking tube communication with the blue print room above and the office below, and telephone communication with three 'phones in the general office and six in the different shops.

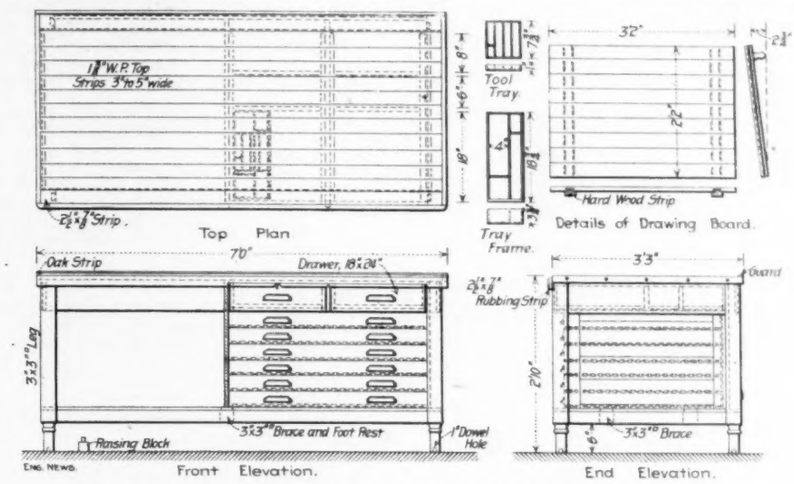


FIG. 3. PLAN, ELEVATIONS AND DETAILS OF DRAWING TABLE.

All drawings and information about drawings are filed in a fireproof vault in filing cases designed for the purpose. All drawings are standard size 24 × 36 ins. and filed flat in drawers 26 × 38 × 2 ins., having the long side facing out, so that the long edge of the drawings strike the long side of the drawer when opening and closing the drawer. This, together with a lid 6 ins. wide at the top and back of the drawer, prevents the drawings from creeping out or rolling up at the back. All small papers, letters, etc., pertaining to each set of drawings, are filed in the vault in an envelope 10 × 15 ins., marked with the same filing number as the drawings.

Fig. 3 is a drawing of the drafting table with six large drawers which is used by the engineer and squad masters. The tables used by the other draftsmen have only two or three large drawers. All tables have the two small top drawers 18 × 24 × 4 ins., one with lock and key; this drawer being provided with tray frame and tray for tools as shown by the drawing, Fig. 3. Vertical adjustment of this table is secured by means of a dowel and raising block 1, 2 or 3 ins. high, according to the wishes of the draftsman.

Drawing boards 26 × 38 ins. taking a standard sized drawing and inclined about ¼ ins. in 12 ins. are used on top of the table. When a large drawing is desired the whole top of the table is available, being made of 1⅛ soft white pine. The table may be independently adjusted and perfect contact is secured without the use of any padding except the mat. A heavy cardboard laid over the mat gives a smooth surface for the paper and tracings to rest on, and takes out any small inequalities or wrinkles of the mat, insuring a perfect print. The hanging racks are vertically over

by the use of the drawers, answers for reference table and filing of old pencil drawings and blue prints while a job is being worked up. With this arrangement the draftsman may use two drawing boards on one table, and boards may be put between tables, one end resting on the table behind and the other on his own. This enables a drafts-

man to have the use of two or three boards if necessary. Small lay out boards are also provided for laying out large details of joints and special connections. The tables are made in oak with natural rubbed finish, presenting a pleasing appearance, and altogether the arrangement surrounds the draftsman with every convenience for doing his work.

The blue print room with all its arrangements for washing and hanging prints, also the printing by sunlight and electric lights are fully illustrated by Figs. 4, 5 and 6, and need little explanation. The blue print frames are operated by lifting the hinged top with the glass by means of the counterweight. The frame is locked and unlocked with one throw of the lever, tightening and loosening the four cams at one time, and any degree of contact can be secured by these cams. The bars underneath carrying the hinges and cams are each independently adjusted by means of thumb screws, a heavy coil spring on these screws preventing any undue pressure being applied. By means of wedges each square foot of the frame

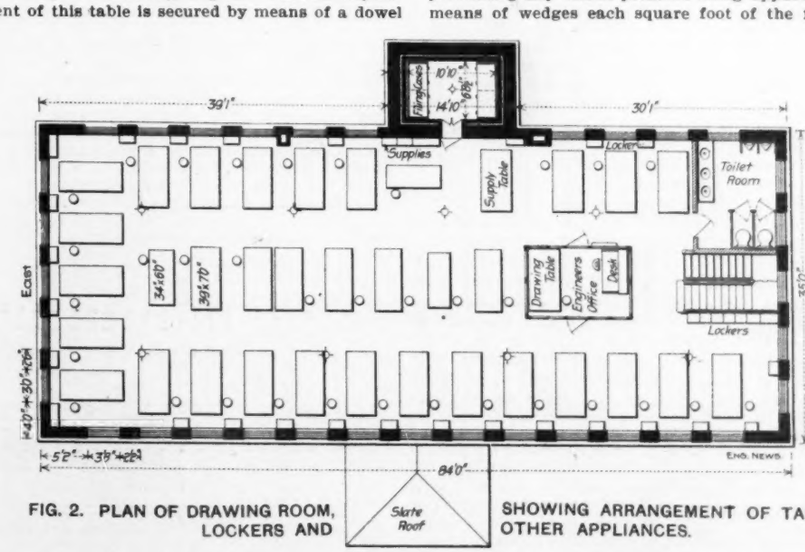


FIG. 2. PLAN OF DRAWING ROOM, LOCKERS AND SHOWING ARRANGEMENT OF TABLES, OTHER APPLIANCES.

the washing tank and take care of the drip without wetting the floor or taking up additional room.

A ¾-in. round stick with a cross piece 3 ins. long at each end is laid in the groove in the bottom of the tank, the print is laid over this and when

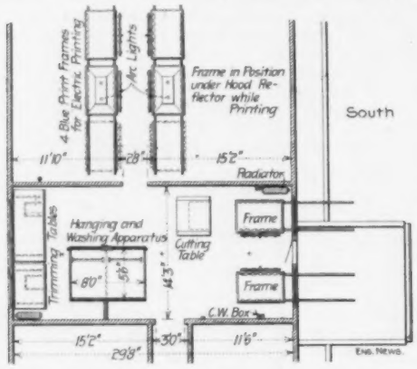


Fig. 4. Plan of Blue-Print Room.

washed the stick with the print hanging from it is laid in the rack above. The 3-in. cross pieces at ends space the prints in the rack so that they do not come in contact. As the racks are filled, the prints at the lower end are taken out and trimmed and the process goes on. As each print contains two standard 24 × 36-in. drawings, the racks when filled will hold 80 standard drawings or more than a 50-yard roll of blue print paper.

The drawing tables, filing cases, engineer's office and blue print frames were manufactured by the Hein Furniture Co., of Toledo, from plans furnished by the Bridge Company.

SHOULD THE SIDE BEARINGS OF FREIGHT CARS BE IN CONTACT?

The question whether the body bolsters of freight cars should or should not rest on the side bearings of the truck bolsters continues to be debated by the railway clubs, developing very opposite opinions and experience, but the general trend of the discussion seems to point to the fact that the bearings should not be in contact unless some form of anti-friction bearing is introduced, in order to prevent the weight of the body and load from binding the truck and preventing it from properly adapting itself to the curves and tangents. This question was discussed at some length in our issue of June 20, 1901, and it formed the most important part of the discussion of a paper on "Car Bolsters," read recently before the Western Railway Club, in Chicago, by Mr. R. P. Lamont, Vice-President of the Simplex Railway Appliance Co. In this paper he stated that he had examined 1,000 loaded cars of all sorts and conditions and from numerous railways. Of these, 60% were equipped with some form of the old style bolster, while the balance had different designs of steel bolsters. Of the 600 cars with old style bolsters, 91% were riding hard on the side bearing; of the 400 cars with steel bolsters, 28% were hard on the side bearings. Leaving aside the question of bolster design, we give herewith an abstract of the discussion on this paper, so far as it relates to the side-bearing question:

Mr. J. J. Hennessey (C., M. & St. P. Ry.).—I fully agree with the author that a large percentage of body and truck bolsters placed under heavy capacity cars built at the present time, are not strong enough to carry the load free from the side bearings. The question which presents itself to my mind is, "Is it advisable to strive to carry the full load on the center plates only?" The object of so doing would be to reduce the flange wear to the minimum by having the car round the curves more easily. I do not see what can be gained in constructing cars with the idea of carrying all the load on the center plates only, as the weight cannot be so confined in actual service. We agree that there is no objection to having the load rest heavily on the side bearings while the car is on a straight track. We all understand that the outer rail of a curved track is from 1 in. to 4 ins. higher than the inner rail, and when the car strikes the curve, the momentum will tilt the car body toward the outside or higher rail, thereby resting the car body heavily on this side bearing as well as on the center plate, and it is thus bound on two points at the very moment it should be free to curve. The object sought, namely, keeping load free from side bearings, is therefore lost. Furthermore, where there is much play between the side bearings, and when the car passes immediately from one curve to a reverse curve at a high rate of speed, whatever play there is between the side bearings must be transmitted from one side to the other and this done very quickly, and this jerky rocking and racking of car is very detrimental to the car body. It must also be borne in mind that when the car strikes the reverse curve, the inside side bearing which was bound on the first curve is now free, and the opposite side bearing is bound so that it prevents free curving.

As a remedy for these evils, I would say that it is my opinion that the car should be constructed with the idea of carrying the load on six points instead of two, and this accomplished by the use of properly constructed side bearings which wil yield on curves without causing friction. There will then be no play between the side bearings, and when the car strikes a curve the truck will immediately curve instead of being held by the side bearings as is now the case. The result on the bolsters would be less failures, due to the strain being distributed instead of being confined to one point.

Mr. C. A. Schroyer (C. & N. W. Ry.).—I fully agree with Mr. Hennessey in regard to carrying the load on two points. I have always considered that a mistake, and yet, try as hard as we may, we have never been able to correct it, and carry the load successfully. We must maintain uniformity, confine ourselves within certain limits of bolsters in order to maintain our draft rigging at the proper height without materially changing our draft timbers, or without materially changing our trucks. I believe the thing for us to give our attention to, more particularly than any other point of bolster construction, is the side bearing question. I designed at one time, for my own information, a truck that had a bearing on the truck and on the body bolster 4 ft. 7 ins. wide. I never put the truck into service, but I believe that that truck would run just as well as many of the trucks I have seen to-day. Instead of having a center plate, I had nothing but a flange and a collar which would hold the trucks separately under the body and gave it 4 ft. 7 ins. length, which length had a motion of over 3 ins. at the side bearings. What we need to-day, a great deal worse than we need the stronger bolster, is perfect side bearings, which will enable us to carry the loads equally on three points instead of one as we are now endeavoring to do.

Mr. W. H. Marshall (L. S. & M. S. Ry.).—I believe that if sufficient thought had been devoted to perfecting side bearings of an anti-friction character, we would not now be putting heavy bolsters in our cars, in an attempt to carry the whole load on the center plate. The questions of weight, cost and space are all against us, and yet we continue attempting to get a bolster that will do business under those conditions. Many roads have 60,000-lb. cars equipped with the wooden truck bolsters and a very weak body bolster. A metal truck bolster in these cars will not help matters very much, because the body bolsters are not strong enough to keep the side bearings out of contact. As long as these side bearings are going to be in contact anyway, it seems to me that the railway has an opportunity to experiment with anti-friction bearings on cars of this character; they can be put in with the wooden bolster at a small expense and will relieve the friction at the side bearings. Experience will thus be obtained without going into thousands of cars at a time, which would have to be the case if one applies them to new cars.

Mr. Hennessy.—We took three cars of 60,000 lbs. capacity, and loaded each car with about 62,000 lbs. of cast-iron wheels. One of the cars was down solid on the side bearings, one car had anti-friction side bearings, and the other car had ⅝-in. play on each side, carrying all the load on the center plates only. We took them to an elevation in the track and there cut them loose and let the cars run down. The first car was the one that was carried on the center plates only. In dropping down through the

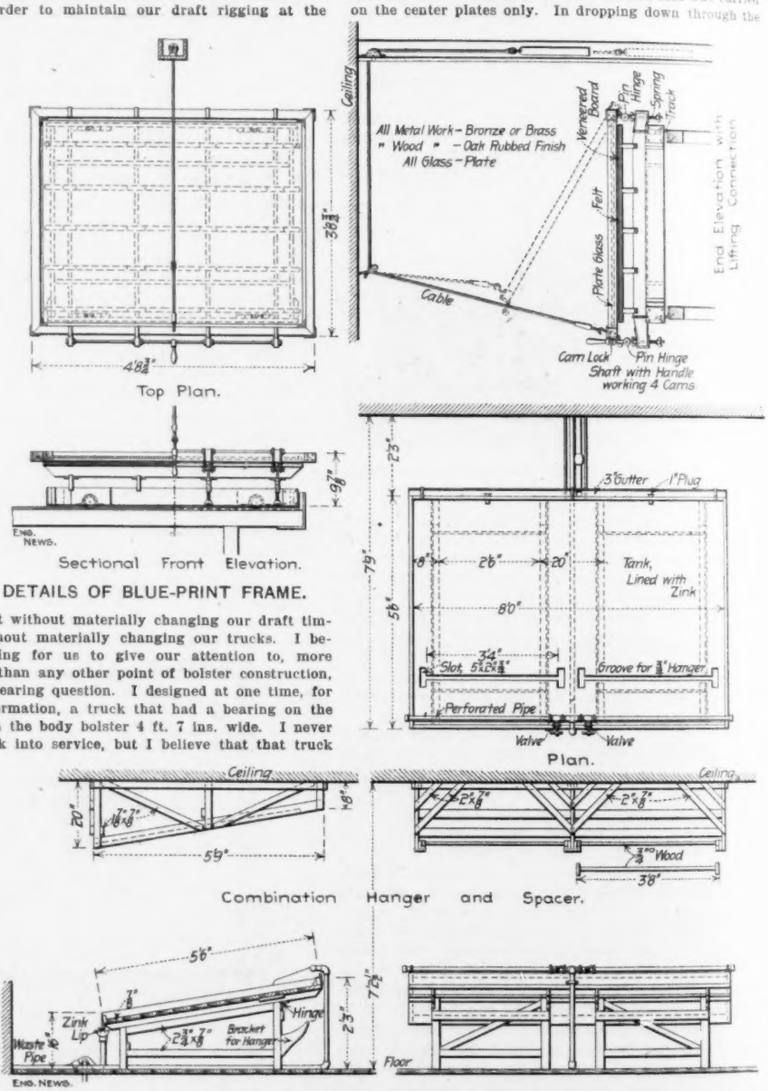


FIG. 6. DETAILS OF BLUE-PRINT FRAME.

FIG. 5. DETAILS OF BLUE-PRINT, WASHING APPARATUS AND DRAWING RACK.

yard track (we ran it into the yards) it had to go over several curves and reverse curves. We were of the opinion that that car would travel the greatest distance, but to our surprise the next car we cut loose (the car that was solid on side bearings, with no play) traveled (as I recollect now) about 150 ft. further than the car that had ⅝-in.

clearance on each side bearing. Then we cut the third car loose, which had anti-friction side bearings; that traveled within about 4 ft. of the place where the one that was resting solid on its side bearings stopped. We made a second and a third test, with the same result, that the car that had the ⅜-in. play on each side bearing, ran the shortest distance.

We found that when it struck the reverse curve, the car came over and caught on the side bearings so solidly and so quickly that it seemed to check the motion of the whole truck and car, and that is the only way that I can account for the car that was carrying all the load on the center plates traveling the shortest distance.

Mr. Frank Slater (C. & N. W. Ry.).—I do not think a test of that kind could be relied upon. The test should be made with the same car, changing the side bearings as each test was made. There is a difference between the running of cars, even if they are built in the same shop.

Mr. Schroyer.—What I had in mind when I spoke of carrying the load on three points, was in getting a side bearing which would always permit the truck to maintain its normal position under a car, and when the swiveling of the truck under the body occurs, that it should assume that normal position again by having the side bearings so constructed that it would force the truck back to an equilibrium without any pressure being exercised through the wheels or the rail head. I think if that were done, the difficulty in rounding curves would be obviated, because the swiveling would be of such character as to always have a tendency to go back to its normal position without being forced to leave a curve and go at a tangent.

Mr. J. W. Hill (P. & P. U. Ry.).—In regard to carrying the weight on the center plates. We have practically all been doing this for years, or making an effort to do it, and I am not yet prepared to admit that the theory is wrong. The company I am with has four classes of coal cars, viz.: 30,000, 50,000, 60,000 and 80,000 lbs. capacity. They run out to the coal mines, where the track is not the best in the world, and at one time we had considerable trouble with the 50,000-lb. cars leaving the track. This class of cars had very weak body bolsters, consequently they were down solid on the side bearings. On every car that was derailed I found it resting heavily on the side bearings. None of the other three classes of cars left the rails. The trucks being all of the same general design, I am forced to the conclusion that the heavy load on these side bearings was the cause of the derailments. The cars of less and also greater capacity than 50,000 lbs. in the same service and same trains gave no trouble.

A Member.—I do not believe that would happen if we used an anti-friction side bearing, because as far as the irregularity of the tracks is concerned, there are springs under the truck, and the body and truck bolster can settle thoroughly with each other, and yet the truck adjust itself to any inequality of the track. I think the reason cars derail on account of the side bearings is because of the friction between bearings preventing the truck from righting. We recently had a case on the Superior & Western, where our largest ballast cars loaded heavily with gravel and going through a very sharp curve actually cut a flange off the wheel; the wheel was in sound condition, but it took the flange right off.

I want to say something about the clearance. About two years ago we had one lot of 80,000-lb. cars with metal body and truck bolsters, very heavy ones, and anti-friction side bearings, with probably about ½-in. clearance, which was more than we intended, but there was an error made, and our inspectors did not catch it. A great many of those side bearings broke, while bearings which were in actual contact, running under some other cars, gave no trouble, and the repairs were practically nothing; the same side bearings in passenger cars we never heard from from one year to the other, and we came to the conclusion that in the first instance the breakages was due to the fact that the clearance was excessive. There are very heavy blows at times on the side bearings, and we are not careful enough in the construction, but if they are properly constructed so that whatever blow does come is taken fairly on all parts that are intended to take pressure, I do not see why they should break at all.

Mr. H. G. Hetzler (C., B. & Q. R. R.).—In regard to the side bearings, it should be remembered that it is possible to load a car with certain kinds of freight so that quite an amount of the load will be carried on the side bearings instead of the center bearing, and therefore the side bearings should be designed to meet these conditions.

Mr. Lamont.—As to carrying part of the load at the side bearings, I suggested that at least nothing could be gained by attempting to do this. I believe it would be difficult to divide the load so that it would be carried at three points, or six points in the car; that is to say, while we are now practically doing this very thing, the bolsters are designed with the idea of carrying the load at the center and we could not safely make them any lighter. We would have an indeterminate problem, and would have to design for the worst possible condition, viz., carrying the load at the center. I do not believe we are going to make bolsters any lighter than they are to-day; if anything, they are going to be heavier, and if we attempt to make them lighter, with the idea of carrying the load at three points instead of at the center, they will fail in other directions; if we make the bolster any thinner or any lighter than it is now, it will deteriorate too rapidly, and it seems to me this is a question to be considered. It seems to me that it is important to carry the car at the center and allow for the swiveling motion of the truck and to enable it to accommodate itself to the unevenness in the track; and I believe there is no doubt but that a great many wrecks are caused on account of the cars bearing too hard on the side bearings; at least that is the apparent reason.

Mr. Ira C. Hubbell (Locomotive Appliance Co.).—I want to call attention to an experiment made by the M., K. & T. Ry. not long ago, where they took a train of cars and blocked the side bearings, so that the cars were all heavy on the side bearings, and then determined the force that was required to move the train. Then these blocks were removed and another test made; the result obtained showed manifestly to the effect that the cars bearing heavily on the side bearings required a great deal more power to move the train. This experiment was conducted with the same cars, the same engine and the same crew.

Mr. W. H. Wickhorst (C., B. & Q. Ry.).—The last speaker has just brought to my mind some tests that we made not long ago with the use of a dynamometer car. We took a train an ran over a piece of track with the cars in their normal condition, just as they came into the yard, and most of them were loaded with coal. We ran at speeds of 10, 15, 20 and 25 miles an hour and had a speed gage on the engine, so the engineer could keep the speed as near uniform over a stretch of track as possible, and in working up the results we figured out the results to pounds per ton, corrected for grade and corrected for acceleration, so as to get the mere rolling resistance or normal moving resistance to that train. We took the same cars, jacked them all up, poured oil into the center plates so as to have the center plates full of oil, and swabbed the side bearings well with oil and made the tests again with the same cars, and the result of the test showed that on either curve or straight track there was no difference in the moving resistance of those cars, showing that lubrication of center plates and side bearings had no effect.

Mr. Lamont.—The resistance introduced at the side bearings has, on an average, a leverage of about ten times that of the resistance at the center plate. The average distance of the bearing surface of a center plate from the center would be about 3 or 4 ins., and the average distance from the center plate to the side bearings is about 30 ins.; a resisting force applied at the side bearings is therefore ten times as effective as at the center, so that there would seem to be an advantage in having the load carried at the center, as far as ease of turning of the truck is concerned. But, of course, if some form of anti-friction side bearing is used (rolling friction, I believe, being about 1 1-100 of sliding friction), it would in a way answer the argument, or would offset the objection to carrying a part of the weight at the side. The question is whether it can be safely done, whether we will ever know where we are carrying the load, and whether anything would be gained by designing weaker bolsters. The workmanship and all the conditions in actual practice would make it almost impossible to divide the load equally between those three points, and the question is, whether the weight would not sometimes be carried at one point and whether you would not have to design your bolsters to meet this worst condition.

Mr. O. M. Stimson (Swift & Co.).—A certain lot of cars were turned out of the shops new with 3-16-in. clearance between the body and truck side bearings on either side. They were hardly out of the shop before a large number of derailments were reported. The road operating the cars decided, after making what they considered a thorough investigation, that the trouble wa caused by not having sufficient clearance between the side bearings, and immediately proceeded to increase the clearance, until they had reached ½-in.; as the clearance was increased the number of derailments also increased, until it was almost impossible to operate the cars. They then adopted the opposite course by reducing the clearance between the side bearings until they found that by introducing side bearings with chilled faces and eliminating the clearance entirely—that is, by bringing the chilled surfaces of the body and truck side bearings into contact—the derailments were almost entirely stopped.

Mr. Schroyer.—I know it to be a fact that on a large number of ore cars where the load is heavy and carried on the side beairngs, there have been hundreds of top bolsters broken on those cars, and yet the cars ran successfully with the top bolsters broken right through the center and the load carried on the side bearings, and I have never known of a single one of those cars being derailed on account of that fact.

NOTES FROM THE ENGINEERING SCHOOLS.

UNIVERSITY OF ILLINOIS.—The agricultural experiment station of this institution, in co-operation with the Bureau of Soils of the U. S. Department of Agriculture, has commenced an agricultural survey of the soils of Illinois. In this survey the soil is carefully examined to a depth of 3 to 6 ft. by earth augers. From the samples obtained soil maps are constructed, showing the area and character of different soils. The party now out expects to survey 1,000 square miles this season.

CLARKSON SCHOOL OF TECHNOLOGY.—Thus far the number of women who have taken engineering courses of study in any of the American engineering schools has been extremely small. This condition may be changed at the Clarkson school at Potsdam, which has just announced the establishment of a course in "domestic engineering." The chief object of the course is to prepare its graduates to teach the technical branches of "home science," such as are now called for in many public schools, and just why it should be called domestic engineering is not apparent.

THE RUSSIAN PETROLEUM OUTPUT for 1901 from the three great Baku oil fields was 80,945,247 barrels of 42 gallons each. This is an increase over 1900, when the production was 72,018,743 barrels. The production from flowing wells accounted for 12,059,332 barrels in the total for 1901. Deducting loss and oil used for fuel the net production was 71,583,401 barrels out of the 80,945,247 barrels. The average price for the year 1901 of the crude oil at the well per barrel of 42 gallons was 32.67 cts.; of residuum at Baku, per gallon, 0.91 cts.; of refined oil f. o. b. on the Caspian Sea, per gallon, 0.82 cts.; refined oil in tank cars at Baku, per gallon, 1.1 cts. At the close of 1901, 1,354 wells were classed as producing, and 1,003 wells stood idle. A very full report on this industry has been made to the State Department by U. S. Consul James C. Chambers, of Batum.

NEW TYPES OF FREIGHT LOCOMOTIVES ON THE ATCHISON, TOPEKA & SANTA FE AND NORTHERN PACIFIC RYS.

For about five or six years the Atchison, Topeka & Santa Fe Ry. has been carrying on a systematic development of its motive power equipment in order to handle the increasing traffic and increasing train loads with facility and economy. Not only have the size and weight of the engines been increased materially, but new designs and special features of construction have been introduced in both freight and passenger engines, including particularly the use of tandem-compound cylinders, a marine type of boiler, a traction-

Comparative Dimensions of Heavy Modern Freight Locomotives.

	A., T. & S. F. Ry.		M., St.P. & S. S. M. Ry.	B. & L. E. Ry.	Union Ry.	Illinois Central	
Type	Decapod.	Consolidat'n	Decapod.	Consolidat'n	Consolidat'n	Consolidat'n	12-wheel.
Builder	American.	Baldwin.	Baldwin.	Pittsburg.	Pittsburg.	Rogers.	Brooks.
Driving wheels	4 ft. 9 ins.	4 ft. 9 ins.	4 ft. 7 ins.	4 ft. 6 ins.	4 ft. 6 ins.	4 ft. 9 ins.	4 ft. 9 ins.
Wh'base, driv'g	20 " 0 "	15 " 4 "	19 " 4 "	15 " 7 "	15 " 7 "	16 " 3 "	15 " 9 "
Total	28 " 11 "	24 " 6 "	28 " 0 "	24 " 4 "	24 " 0 "	24 " 5 "	28 " 6 "
W't on drivers	232,000 lbs.	191,370 lbs.	184,300 lbs.	225,000 lbs.	208,000 lbs.	198,000 lbs.	193,200 lbs.
Engine	259,800 "	214,670 "	207,210 "	250,300 "	230,000 "	218,000 "	232,200 "
Eng. & tendr		324,600 "	327,200 "	391,400 "	332,000 "		364,900 "
Cyl'd'rs, h.-p. (2)	17½×34 ins.	17 x 32 ins.	17 x 32 ins.	24 x 32 ins.	23 x 32 ins.	23 x 30 ins.	23 x 30 ins.
L.-p. (2)	30 x 34 ins.	28 x 32 ins.	28 x 32 ins.				
Boiler, diam	6 ft 6⅝ ins.	6 ft. ½-in.	5 ft. 6⅝ ins.	7 ft. 4 ins.	6 ft. 8 ins.	6 ft. 8 ins.	6 ft. 8 ins.
Pressure	225 lbs.	210 lbs.	215 lbs.	220 lbs.	200 lbs.	210 lbs.	210 lbs.
Firebox, length	9 ft. 1/16-in.	7 ft.	11 ft. 11 ins.	11 ft. 0 ins.	10 ft. 0 ins.	11 ft.	11 ft.
Width	6 " 7⅛ ins.	(3) 28" diam.	3 " 5⅛"	3 " 6¼"	3 " 4¼"	3 ft. 6 ins.	3 ft. 6 ins.
Tubes, No.	413	652	344	406	355	417	424
Diameter	2¼ ins.	1¾ ins.	2 ins.	2¼ ins.	2¼ ins.	2 ins.	2 ins.
Length	18 ft. 6 ins.	13 ft. 7 ins.	15 ft. 7 ins.	15 ft.	15 ft.	13 ft. 8 ins.	14 ft.8⅜ ins.
Heating surface:							
Tubes	4,477 sq.ft.	4,031 sq.ft.	2,792 sq.ft.	3,564 sq.ft.	3,116 sq.ft.	2,951 sq.ft.	3,237 sq.ft.
Total	4,682 "	4,266 "	3,016 "	3,805 "	3,322 "	3,203 "	3,500 "
Grate area	50.5 "		37.5 "	36.8 "	33.5 "	38.5 "	37.5 "
Water	7,000 galls.	6,000 galls.	7,000 galls.	7,500 galls.		5,000 galls.	7,000 galls.
Coal	11 tons.	11 tons.	20,160 lbs.	28,000 lbs.		10 tons.	28,800 lbs.
Oil	2,250 galls.	2,200 galls.					
In Eng. News	Pres. issue.	Pres. issue.	Sept. 20, 1900	June 21, 1900.	Oct. 27, 1898.	May 17, 1900.	Oct. 26, 1899.

Note.—One of the A., T. & S. F. consolidation engines has three 28-in. furnaces; others almost identical have fireboxes 8 ft. × 5 ft. 11 ins. Some of the engines burn coal, others burn oil.

increasing device, and the substitution of oil for coal as fuel. Another interesting development is the adoption of the decapod or ten-coupled type of locomotive for regular use in heavy freight service, for up to the present time engines of this type have been used in comparatively small numbers and for exceptional conditions of service. This innovation is due to Mr. J. W. Kendrick, Third Vice-President. The new freight motive power equipment already ordered or being delivered, in which the above special features are embodied, includes the following: First, 36 consolidation engines from the same general type) is now being tried on a large number of roads. The marine boiler was first experimented with on the Atchison, Topeka & Santa Fe Ry. about two years ago, as noted in our issue of Feb. 22, 1899. This experimental boiler was of the return-tubular pattern and had several peculiar features. The single corrugated furnace and the combustion chamber extended the entire length of the barrel, the return tubes leading to a chamber on the back head (in the cab), from which two flues led back along the boiler to the smokestack. This boiler was applied to a consolidation freight

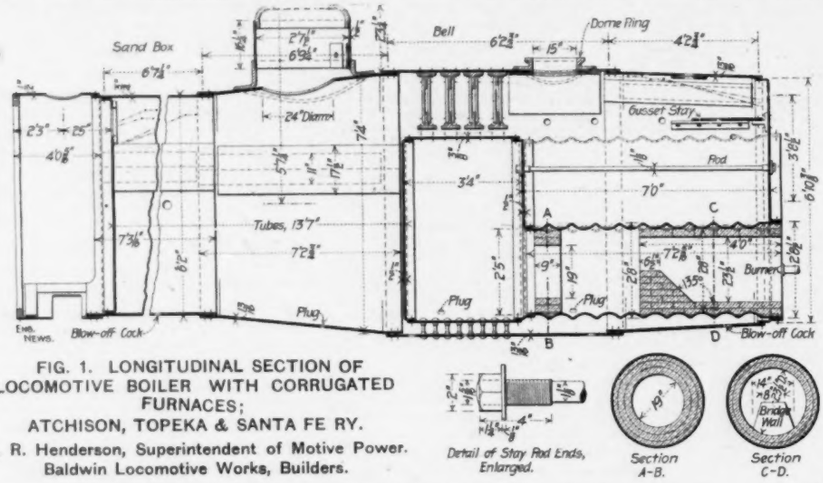


FIG. 1. LONGITUDINAL SECTION OF LOCOMOTIVE BOILER WITH CORRUGATED FURNACES;
ATCHISON, TOPEKA & SANTA FE RY.
G. R. Henderson, Superintendent of Motive Power.
Baldwin Locomotive Works, Builders.

the Baldwin Locomotive Works; of these one has a marine boiler for oil fuel, and the others have the ordinary coal burning style of boiler with firebox 8 ft. × 5 ft. 11 ins. at the grate; Second, 2 four-cylinder tandem-compound decapod engines from the American Locomotive Co., with fireboxes 9 ft. × 7 ft. 7 ins., but bricked up for the use of oil fuel; Third, 74 four-cylinder tandem-compound decapod engines from the Baldwin Locomotive Works; 50 of these will have the marine type of boiler and use oil fuel, while 24 will have fireboxes 9 ft. × 6½ ft. for burning coal.

For drawings and information respecting these engines we are indebted to the builders and to

engine now used in switching service, but it has not proved a success.

The present form of corrugated-furnace boiler now being used on this road, was designed by Mr. George R. Henderson, M. Am. Soc. M. E., Superintendent of Motive Power. As shown in Figs. 1 and 2, it is not return-tubular, but has tubes leading direct to the smokebox, as in the Strong and Vanderbilt boilers. The diameter of the shell at the back head is 6 ft. 10⅝ ins., increasing to 7 ft. 4 ins. at the tube sheet, which is 6 ft. 2¾ ins. from the back head. There is then a conical or taper course 6 ft. 9¼ ins. long, reducing the diameter to 6 ft. 2

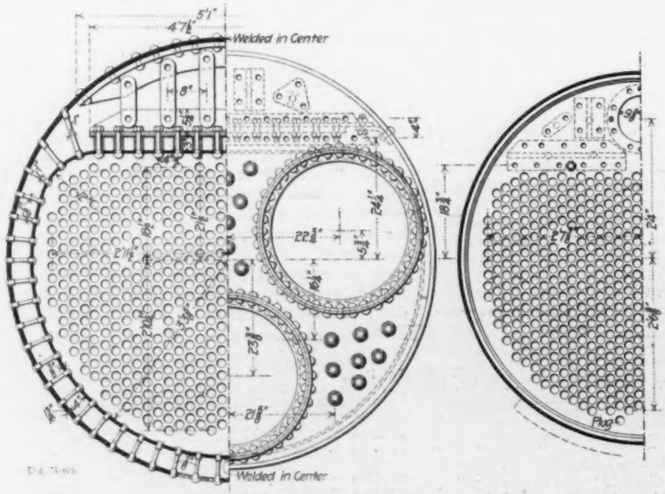


FIG. 2. CROSS-SECTIONS AND END ELEVATION OF BOILER WITH CORRUGATED FURNACES.

the officers of the railway, and the accompanying table shows how the engines compare with other notable engines in similar service.

CONSOLIDATION ENGINES WITH CORRUGATED FURNACES.

The marine type of boiler with corrugated furnaces and a combustion chamber was used by Mr. Strong in the experimental engine which was used on the Lehigh Valley R. R., Erie R. R., etc., some years ago, while the Vanderbilt boiler (of ins., followed by a cylindrical barrel course 6 ft. 7¼ ins. long, and a short smoke box, 4 ft. 1¾ ins. long. The longitudinal seams are welded for a length of 9 ins. at each end. In the back end are placed three Morison corrugated furnaces, 28 and 32 ins. minimum and maximum diameter, with a length of 7 ft. 2 5-16 ins. These are riveted to flanged openings in the ½-in. plates of the back head and the combustion chamber. Stay rods 1⅛ ins. diameter are screwed through these plates, while the back head is also stayed to the shell by diagonal rods and horizontal gusset plates. The combustion chamber is [illegible] 4 ins. long, with a flat crown sheet supported by T-shaped crown bars and slings. The sides and bottom are of 3 ft. 3⅝ ins. radius, giving a 4-in. water space, and are connected to the flat crown by curves of 12 ins. radius. From this chamber extend the tubes, which are 13 ft. 7 ins. long. The dome is placed on the taper connection sheet and is 31½ ins. diameter, riveted to the inside of a flanged ring or collar on the boiler. The opening in the boiler shell is 24 ins. diameter, and has no inside reinforcing ring. A separate dome, over the firebox, is provided for the attachment of the safety valves.

The engine is intended to use oil fuel, as already noted, and in Fig. 1 is shown the arrangement of the brick lining of the furnaces. This lining reduces the diameter to 23½ ins. for a distance of 4 ft., at which point there is a pyramidal bridge wall, with open space on each side between the wall and the lining. The furnace is then left unlined for a short distance, but at the end is another brick ring 9 ins. long, which reduces the diameter to 19 ins. and serves to protect the flanged joint connection with the back plate of the combustion chamber. Fig 3 shows the piping from the tender oil tank to the heaters and burners, a nozzle or burner being set at the center line of each furnace. The Booth patent burner is used, and is shown in Fig. 3-A.

The engines are Vauclain four-cylinder compounds. The two cylinders on each side are placed with the low-pressure above the high-pressure cylinder, and with the axis of the chamber of the single piston valve coinciding with the vertical center line of the frames. The two piston rods are attached to projections above and below a flat crosshead working in closely spaced guides placed between the rods. The valve rods are of H section and lie above the two first driving axles; they have their ends bent down to the link connection and the rocker, the latter being below instead of above the rock shaft.

All the wheels have flanged tires, giving a rigid wheelbase of 15 ft. 4 ins., the distance back to back of tires being 53¼ ins. for the first and fourth pairs and 53⅜ ins. for the other drivers and truck. The engines are designed to pass curves of 10° with this arrangement. The two first driving axles have springs above the boxes, the springs being connected together and to the truck springs by equalizers. The two rear driving axles have equalizers seated on the boxes, the inner ends being connected by an inverted plate spring,

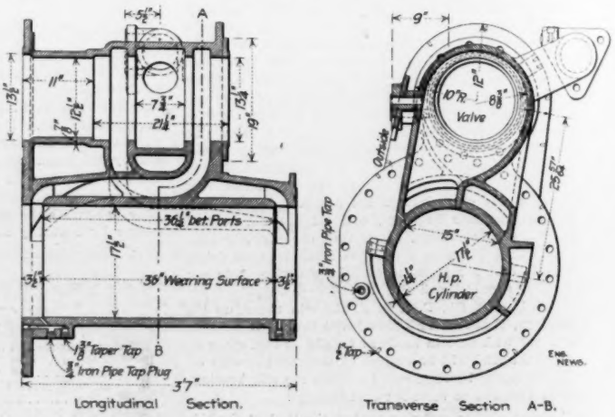


FIG. 9. HIGH-PRESSURE CYLINDER.

while the outer ends carry helical springs, which (like the middle spring) are seated under the top bar of the frames. The frames are an interesting feature, being of cast steel in all the 36 consolidation engines now under construction. The length is 34 ft. 2½ ins. over all. The main casting is 27 ft. 5¼ ins. long, and is of the usual form, but both top and bottom bars are extended beyond the pedestal of the first driving axle, and carry extensions which support the large and ponderous

cylinder and saddle castings. To the top bar is bolted an extension piece, whose outer end is bolted to an intermediate bar bolted to the saddle castings. To the lower bar of the main frame is bolted another extension piece, which also is attached to the saddle casting. The pedestals are connected by bolts below the boxes, spacing sleeves being fitted between the pedestals. The design of the frame is shown in Fig. 4.

A view of the engine with Mr. Henderson's boiler is given in Fig. 5, and from this it will be seen that the engine is of great size and weight; with the exception of the boiler it is practically identical with the 35 other consolidation engines now being built for this road, as already noted.

These engines are intended for use as helpers on mountain grades, also for service on the main line between Seligman and Barstow (318 miles), where our grades are very heavy, being 75 ft. per mile against westbound, and 90 ft. per mile against eastbound traffic. These engines will have 230,000 lbs. on drivers and will be tandem-compounds, the cylinders and appurtenant valves being constructed according to designs furnished by our Motive Power Department and modified somewhat by Mr. Vauclain. We now have two engines of this type on the road. These were built by the American Locomotive Works, at Schenectady, in order to demonstrate the utility of the type before constructing any considerable number. In my opinion there was only one question involved; namely, the practicability of using engines with a rigid driving wheelbase of 20 ft. upon 10° curves. The engines having been laid out in the designing loft at Schenectady, we found that there was no apparent reason why they will not track satisfactorily upon 16° curves, which is desirable, as we have no turntables at present on which they can be turned.

I adopted the decapod type because we could not secure the requisite tractive power with an engine of the consolidation type without an excessive weight on driving wheels. The Northern Pacific Ry. has had two decapods (which would now be considered very small, having about 130,000 lbs. on drivers) in its service for the past 15 years. These were built by the Baldwin company and have always given good satisfaction. They possess no features which can be called unique, only differing from engines of the consolidation type because of the additional pair of driving wheels. I do not doubt that the new engines will prove entirely successful in our service, in which case it will revolutionize our operating methods on the heavy grade sections of the system.

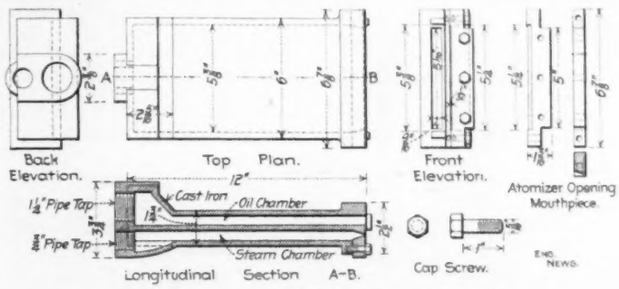


FIG. 3A. OIL BURNER; A., T. & S. F. RY.

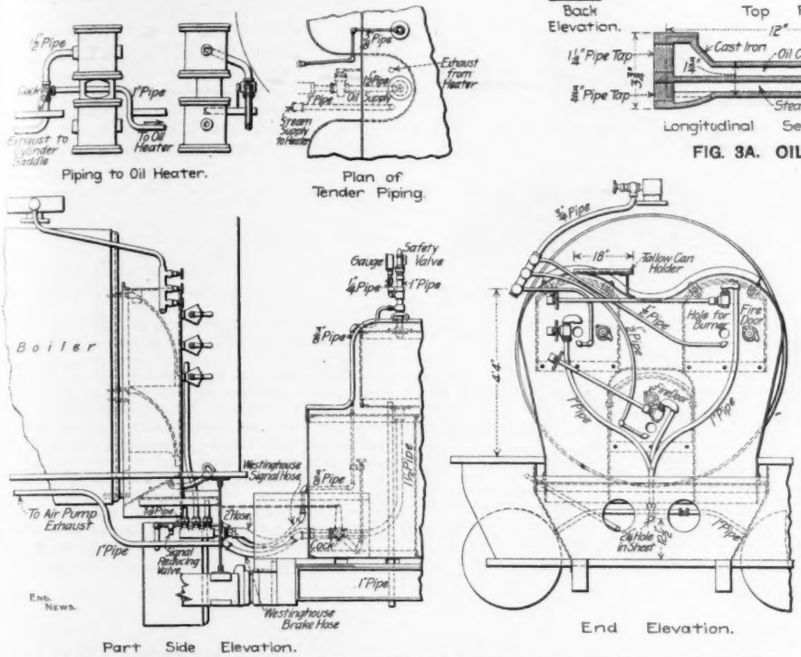


FIG. 3. PIPE CONNECTIONS FROM TENDER OIL TANK TO BURNERS IN FIREBOX.

A list of the leading dimensions is appended to this article.

DECAPOD FOUR-CYLINDER TANDEM-COMPOUND LOCOMOTIVES.

The policy of adopting decapod engines in regular service for heavy freight traffic is somewhat of an innovation in railway operation and has been initiated by Mr. J. W. Kendrick, Third Vice-President of the A., T. & S. F. Ry., who writes us as follows in regard to this policy, and the service which the engines are expected to perform. Their use will largely do away with the present necessity of double-heading freight trains on the heavy portions of the road.

As already noted, 76 engines of the decapod type have been ordered, 2 from the American Locomotive Co. and 74 from the Baldwin Locomotive Works. They will all be four-cylinder tandem compounds, very much alike in most respects, but differing in certain details. It is the American Locomotive Co.'s engines which we describe below. Fig. 6 is a view of one of these immense engines.

The boiler is 6 ft. 5 ins. diameter inside, at the smokebox end, and its center is 9 ft. 10 ins. above the rails. This sets the top of the boiler at such a height that the dome (which is on the wagon-top) has to be made very low, bringing the throttle valve barely above the line of the boiler shell. The 32-in. shell of the dome is riveted to the inside of a flanged ring or collar on the boiler, and the 25-in. opening in the boiler shell is reinforced by an inside plate ring 60 ins. diameter, with a 25-in. hole corresponding to that in the shell. This is a very general arrangement, except that the ring is usually narrower than this, but in the consolidation engines the inside ring is omitted. The back head is inclined, and the front water leg is very short, the firebox only extending 14⅝ ins. below the barrel of the boiler. The firebox is 9 ft. 1 in. long inside, at the grate, or 9 ft. 9½ ins. long and 7 ft. 4 ins. wide over all. The form, shown in Fig. 7, is that used in many of the recent large engines built by the American Locomotive Co., but the detail of the seam in the side plates has been somewhat criticised. The crown sheet has a radius of 6 ft., and is supported by crown bars and radial stays from the boiler shell, which has a radius of 3 ft. 8 ins. The sides are flat, flaring outward from the crown sheet and shell to the mud ring.

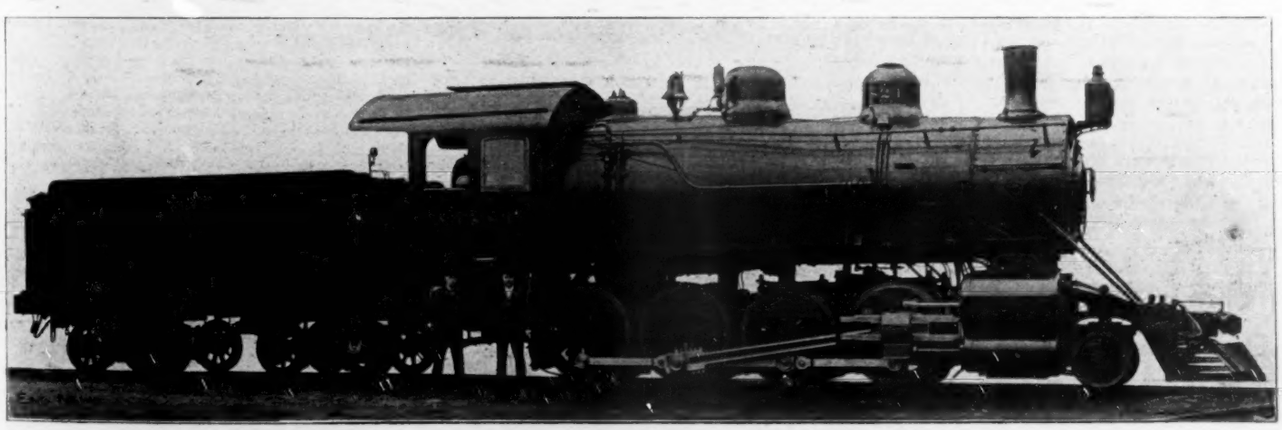


FIG. 5. COMPOUND CONSOLIDATION FREIGHT LOCOMOTIVE WITH CORRUGATED FURNACES, FOR OIL FUEL; ATCHISON, TOPEKA & SANTA FE RY.

The frames are of cast steel, and of special design at the front end to carry the tandem cylinders, as shown in Fig. 8. The pedestals are tied together by heavy bars (instead of bolts, as in the consolidation engines), the bars being dovetailed to the pedestals and bolted to the bottom rail of the frame. The arrangement of the spring rigging is practically the same as in the consolidation engines, except that three rear axles (instead if two) have equalizers seated on the boxes. The springs of these three axles are connected up in one system, while those of the two front driving axles and the truck form another independent system. All the wheels are flanged, giving a rigid wheelbase of 20 ft., but the engines are capable of passing 10° curves. The distances back to back of flanges of the wheels are as follows: Truck wheels, 53⅝ ins.; first, third and fifth pairs of driving wheels, 53⅛ ins.; second and fourth pairs of driving wheels, 53⅜ ins. The decapod engines built by the Baldwin Locomotive Works, however, have blind tires on the third pair of drivers; the first and fifth pairs are 53 ins. back to back, and the second and fourth pairs 53¼ ins. back to back of flange.

A list of dimensions of these engines is given at the end of this article. The 74 Baldwin decapods will be practically identical with those above described, except that instead of cylinders 17½ × 34 and 30 × 34 ins., they will have cylinders 19 × 32 and 32 × 32 ins.; the heating surface will be about 5,800 sq. ft. for the oil-burning and 5,200 sq. ft. for the coal-burning engines; the weight will be about 260,000 lbs., with 230,000 lbs. on the driving wheels. The wheelbase will differ slightly, as follows: Driving, 20 ft. 4 ins.; engine, 29 ft. 3 ins.; tender, 19 ft. 3 ins.; engine and tender, 62 ft.

The coal burners will use what is known as Gallup coal, which is the only kind this road has west of Albuquerque. The oil-burners will use California oil. The sharpest curves on the Southern California division are of 10°, and the maximum grade is 158 ft. per mile (or 3%) for a distance of 6½ miles, between San Bernardino and Summit. The length of run on one district is 100 miles, and on the other 170 miles. The maximum speed in regular service is 24 miles per hour. The train load to be hauled up the grade above mentioned is 650 tons, but it is expected that the engines will do much better than this. In fact, the first of the two engines built by the American Locomotive Co. has taken up a train load of 703 tons.

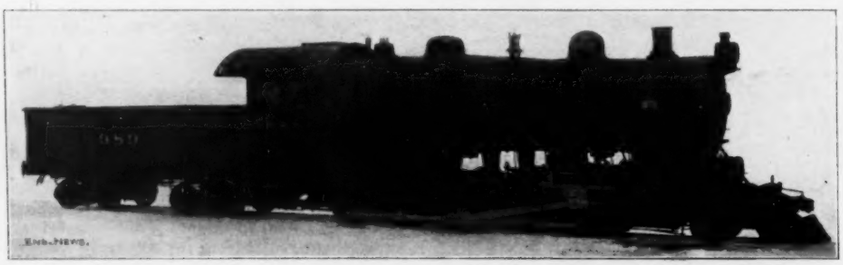


FIG. 6. FOUR-CYLINDER TANDEM-COMPOUND DECAPOD FREIGHT LOCOMOTIVE; ATCHISON, TOPEKA & SANTA FE RY.

G. R. Henderson, Superintendent of Motive Power.
American Locomotive Co., Builders.

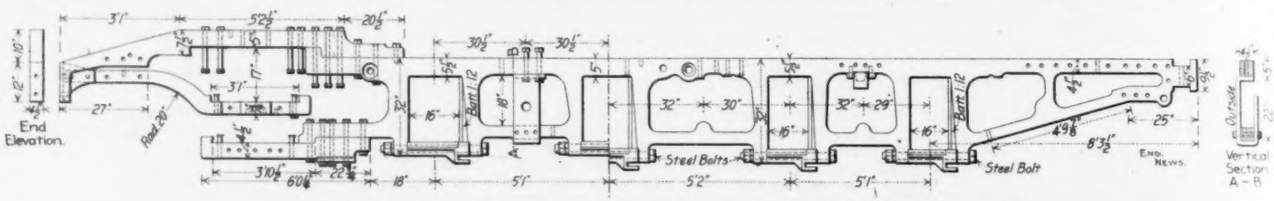


FIG. 4. CAST-STEEL FRAME FOR CONSOLIDATION ENGINES; A., T. & S. F. RY.

One of the most interesting features is that of the compounding. The first tandem-compound on this road was a consolidation engine built at the railway company's shops in 1898; this engine had cylinders 15 × 28 ins. and 25 × 28 ins., and weighed 175,000 lbs. Other tandem-compounds built for the same railway were noted in our issue of Jan. 18, 1900. In these, as in the new engines, the high-pressure cylinders are placed forward of the saddle, the steam pipes being carried through the side of the saddle and forward to the valve chamber. Both cylinders have short piston valves, mounted on one stem, and working in one long valve chamber. The high-pressure valve has inside admission, while the low-pressure valve has outside admission, and the cylindrical valve chamber forms the receiver. The guides are of the Laird type. Figs. 9 and 10 show the cylinders, valve chambers and steam passages, while Fig. 11 shows one of the 12-in. piston valves. The compounding arrangements and their operation are described in further detail below.

FOUR-CYLINDER TANDEM-COMPOUND LOCOMOTIVE; NORTHERN PACIFIC RY.

In connection with the tandem-compound engine for the Atchison, Topeka & Santa Fe Ry., it is interesting to note that in 1900 the Schenectady Locomotive Works (American Locomotive Co.) built a four-cylinder tandem-compound consolidation engine for heavy mountain service on the Northern Pacific Ry. This engine had piston valves on the high-pressure cylinders and slide valves on the low-pressure sylinders. It proved so successful that 26 similar engines were ordered, but having piston valves on all the cylinders; 14 had 63-in. driving wheels and 12 had 55-in. wheels. In these the compounding was the same as in the new engines for the A., T. & S. F. Ry., and the principal dimensions of the Northern Pacific Ry. engines were as follows:

Driving wheels	5 ft. 3 ins.
Wheelbase, driving	17 " 0 "
Total	26 " 2 "
Weight on drivers	175,000 lbs.
Total	198,000 "
Cylinders, h.-p.	15 × 34 ins.
L.-p.	28 × 34 "
Boiler, diameter	5 ft. 6½ ins.
Pressure	225 lbs.
Firebox	8' 4" × 6' 3"
Depth front	5 ft. 10⅝ ins.
Depth back	4 ft. 11¾ ins.
Tubes, No. and diameter	(338) 2-in.
Length	16 ft.
Heating surface, total	2,997 sq. ft.
Grate area	52.3 "

The following description of the compounding features of these Northern Pacific Ry. engines (which correspond very closely with those of the engines for the Atchison, Topeka & Santa Fe Ry.) is taken from a paper on "Recent Locomotive Construction and Performance," read at the November meeting of the New York Railroad Club by Mr. F. J. Cole, Assistant Mechanical Engineer of the American Locomotive Co.:

Piston valves are used for both high and low pressure cylinders, the high-pressure valve having internal admission and the low-pressure external. The piston rod bushing or gland between the high and low-pressure cylinders is arranged so that none of the weight of the rods or piston head is carried on this bushing, as it finds its own center in the cylinder head; it is rendered practically steam tight by the ground joint on the circular flange. This device has proved very satisfactory in service and has required little or no repair during the past year. The live steam is taken from the saddle of the low-pressure cylinder and connected with the high-pressure steam chest by means of a pipe. The high-pressure valve is made for internal admission, which requires the use of the cross ports in the high-pressure cylinder. The inner rings of the valve form the steam edges and the outer rings the exhaust edges. The low-pressure valve is exactly the same as the high-pressure valve, but the ports are arranged for outside admission, the valve chamber being the receiver.

The low-pressure cylinders have very large by-pass valves to facilitate drifting, to avoid working the fire when running down grade and to relieve the cylinders from water. The upper port is in communication with the steam chest or receiver pressure and the lower port with the admission port below the valve of the cylinder. When the engine is working steam the pressure on top of the by-pass valve closes it and so prevents communication between the ends of the cylinder. As the lower end of the valve is open to the atmosphere a difference of 8 or 10 lbs. will cause the valve to seat. If water is allowed to accumulate the valve will open and relieve the excess pressure when the water pressure reaches about 50% increase over boiler pressure. It was found by careful tests and indicator cards that an engine would drift as easily at 20 miles an hour with the large by-pass valves in operation on the low-pressure cylinders, as it would at 18 miles an hour without the valves.

On the high-pressure cylinder the combined by-pass and starting valve is bolted. When the throttle is closed the weight of the by-pass valves allows them to fall open. This permits communication between both ends of the cylinder. The chamber for each by-pass valve communicates with the live steam port and the admission port, so that communication is produced by opening the port and one valve to the live steam port, and in turn passing out

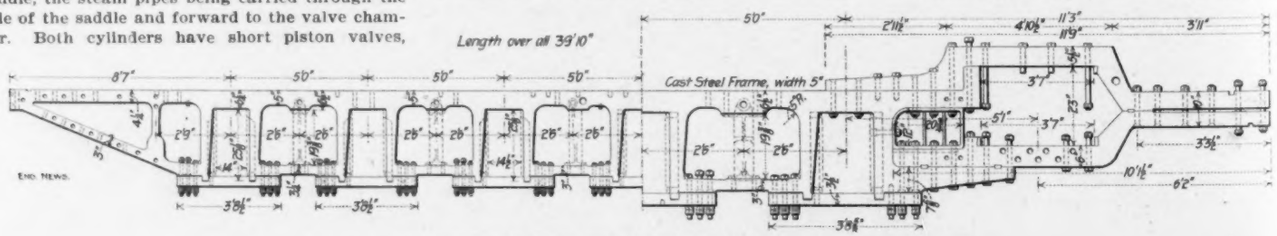


FIG. 8. CAST-STEEL FRAMES FOR DECAPOD ENGINE; A., T. & S. F. RY.

again through the other valve into the other admission port, the live steam port merely acting as a substitute for a pipe. The opening for the admission of live steam to the low-pressure cylinder is controlled by a 1½-in. plug, which when pulled out closes the live steam port. In this position the engine is working compound. When it is desired to start, this plug is pushed in and the 1¼ × 1¾-in port opened, admitting live steam into the receiver and thence into the low-pressure cylinder. The plug is controlled by suitable levers from the cab. The effect of admitting high-pressure steam in this manner is to put the high-pressure piston in partial equilibrium so that the starting is done by means of live steam in the low-pressure cylinder. The dimensions of the live-steam port are such that if the engine slips the piston travels so fast that the steam cannot maintain high pressure, the effect being to automatically wire-draw the supply of live steam.

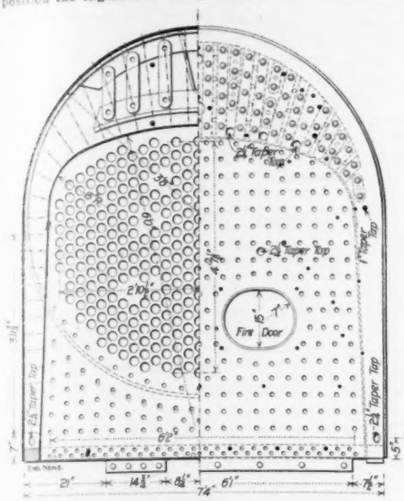


Fig. 7. Cross-Section of Firebox for Decapod Compound Locomotive; A., T. & S. F. Ry.

TRACTION-INCREASING DEVICE.

The use of a traction-increaser has already been referred to. This device has been applied to 35 passenger engines and 40 freight engines, all of the Prairie type, of the Atchison, Topeka & Santa Fe Ry. In these engines, a single cylinder over the front truck axle is connected by levers to the equalizing beam, while two cylinders in front of the rear truck carry a cross-bar which can be raised so as to give a new fulcrum point to the equalizers.

Under normal conditions, the passenger engine has 147,500 lbs. on the driving wheels and 63,300 lbs. on the two trucks; with air admitted to the three cylinders so as to change the fulcrum points, the weight on the driving wheels is increased to 156,200 lbs., and the weight on the trucks correspondingly reduced to 54,600 lbs. The freight engines weigh 190,000 lbs., with 135,000 lbs. on the drivers in normal condition, or 155,000 lbs. with the traction-increasing device in operation. The device is operated automatically from the reversing lever by connections to a three-way valve, which admits air to the operating cylinders when the lever is in full forward or backward gear, and exhausts it when the lever is moved to the center of the quadrant. The engineman can put the traction-increaser out of service if he desires, however.

DIMENSIONS OF NEW FREIGHT LOCOMOTIVES; A., T. & S. F. RY.

We give below, in our standard form, the list of leading dimensions of the new consolidation and decapod freight engines for the Atchison, Topeka & Santa Fe Ry., which have been described in the earlier part of this article:

Dimensions of New Freight Locomotives; Atchison, Topeka & Santa Fe Ry.

	Consolidatn.	Decapod.
Type of engine	Consolidatn.	Decapod.
Builder	Baldwin.	American.
Running Gear: Drvg wheels.	4 ft. 9 ins.	4 ft. 9 ins.
Truck wheels	2 " 6 "	2 " 6 "
Tender wheels	2 " 10¼"	2 " 9 "
Driving wheel centers	Cast steel.	Cast steel
Truck and tender wheels.	Steel tired.	A., T. & S. F.
Tires secured	Shrink. and shoulder.	Shrinkage.
Engine truck	Swing center.	Swing center.
Journals, main axle	9½ × 12 ins.	10 × 12 ins.
Coupled axles	9 × 12 ins.	9 × 12 "
Wheelbase: Driving	15 ft. 4 ins.	20 ft. 0 ins.
Engine	24 " 6 "	28 " 11 "
Tender	17 " 6 "	19 " 3 "
Engine and tender	54 " 2¾"	62 " 0 "
Blind tires	None.	None.*
Weight in Working Order:		
On driving wheels	191,370 lbs.	232,000 lbs.
On truck	23,300 "	27,800 "
Engine	214,670 "	259,800 "
Tender, loaded	110,000 "	134,000 "
Empty	.....	60,000 "
Water in boiler	25,650 "	.....
Cylinders: Compounding	(4) Vauclain.	(4) tandem.
Diam. and stroke—h.-p.	17 × 32 ins.	17½ × 34 ins.
Diam. and stroke—l.-p.	28 × 32 "	30 × 34 ins.
Connectg rod, lngth, c. to c.	10 ft. 10 ins.	.....
Side rods	Solid ends.	Solid ends.
Ratio h.-p. to l.-p. cyl. area	2.713	2.938
Cu. contents, all cylindrs	31.21 cu. ft.	37.28 cu. ft.
Sq. ft. total heat. surf. per cu. ft. cyl. vol.	122.70	.....
Sq. ft. firebox heat. surf. per cu. ft. cyl. vol.	7.53	.....
Sq. ft. tube heat. surf. per cu. ft. cyl. vol.	115.20	.....
Sq. ft. grate area per cu. ft. cyl. vol.	.....	1.569

Boiler:

Diam, inside smallst ring	6 ft. ½- in.	6 ft. 6¾ ins.
Dome, diameter	2 ft. 7½ ins.	2 " 8 "
Barrel plates	13/16 & ¾-in.	13/16, 9/16, 5/8 and 1 in.
Smokebox tube plate	½-in.	½-in.
Seams: Horizntl, riveted.	Double.	Sextuple.
Circumferential, rvtd.	Double.	Double.
Joints	Butt.	Butt, dbl welt
Rivets	1¼ ins.	¾, ⅞, 1 1/16 and 1⅛ ins.
Rail to center line	9 ft. 2 ins.	9 ft. 10 ins.
Smokebox, length	4 " 4 "	5 " 11½"
Injectors, 2 each	Simplex, No. 10	Nath'n, No. 11
Working pressure	200 lbs.	225 lbs.
Firebox	3 corr. flues.	Wide.
Length, inside	7 ft.	9 ft. 1/16-in.
Width, inside	.....	6 ft. 7⅛ ins.
Depth, front	.....	6 " 7½ "
Depth, back	.....	6 " 4½ "

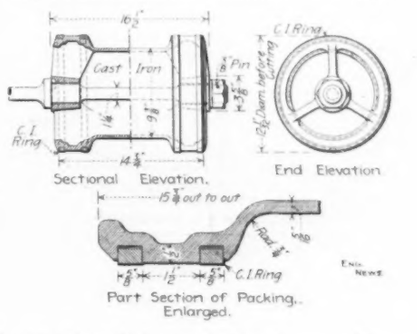


Fig. 11. Piston Valve for Tandem Compound Locomotive.

Diam. furnaces, inside	2 ft. 4 ins.	.....
Combustion chambr, lgth	3 " 4 "	.....
Side and back plates	½-in.	⅝-in.
Crown plate	.....	7/16-in.
Tube plate	½-in.	9/16-in.
Firebrick arch	(Lining.)	Yes, for oil.
Crown stays	.....	Radial, 1⅛".
Staybolts, diameter	⅞ & 1 in.	1 in.
Staybolts, pitch	4 1/16 ins.	3⅞ ins.
Water spaces	.....	f., 4½; s., 4 to 6½; b., 4 to 5½ ins.
Tubes: Material	Iron.	Iron.
Number	652	413
Thickness	No. 13.	No. 11.
Pitch	2 13/32 ins.	.....
Diameter, outside	1¾ ins.	2¼ ins.
Length over tube plates.	13 ft. 7 ins.	18 ft. 6 ins.
Total area, tube openings	8.65 sq. ft.	.....
Heating Surface: Tubes	3,595.5 sq. ft.	4,476.5 sq. ft.
Firebox	165 "	205.41 "
Combustion chamber	70 "	.....
Total	3,830 "	4,681.91 "
Grate area	.....	59.47 "

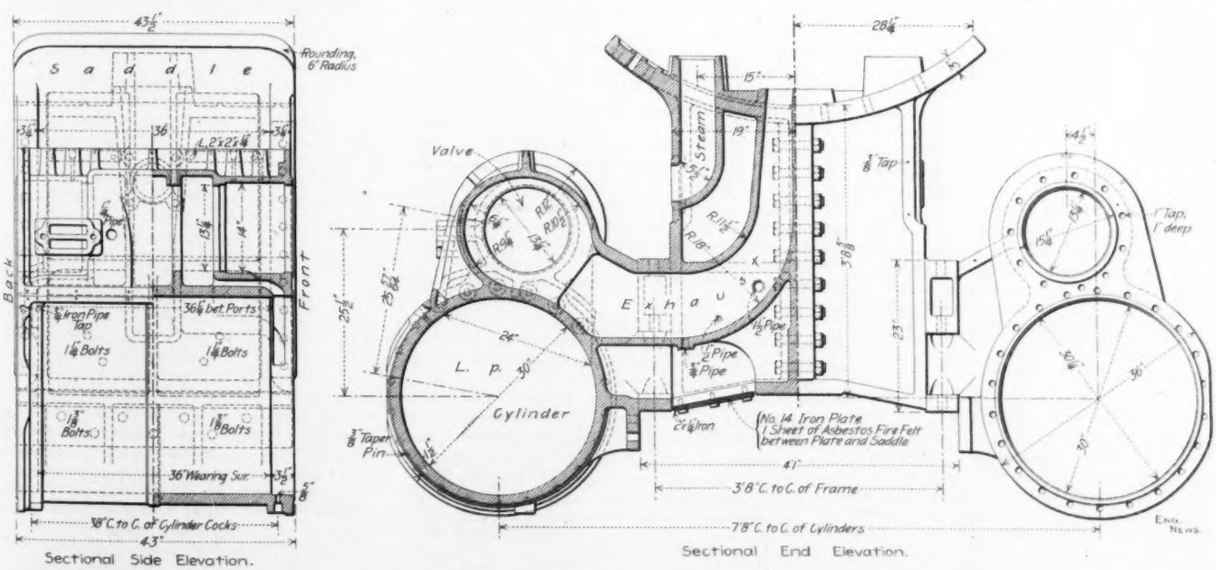


FIG. 10. LOW-PRESSURE CYLINDER AND SADDLE.

Valve Gear: Type	Link.	Link.
Ports, steam	1½ × 29¾ ins.	2 & 2⅞" wide
Exhaust	4½ × 29¾ ins.	3 & 3¼" wide
Bridges, width	2⅝ & 3 ins.	4 & 2¼" wide
Eccentrics, throw	5¾ ins.	6 ins.
Piston valves: Max. travel	5¾ ins.	6 ins.
Diameter	13 ins.	.....
Inside clearance, h.-p.	¼-in.	1/16-in.
Inside clearance, l.-p.	3/16-in.	1/16-in.
Outside lap, h.-p.	1⅛-in.	1⅛-in.
Outside lap, l.-p.	¾-in.	1⅛-in.
Lead (full gear) h.-p.	Nil.	¼-in.†
Lead, (full gear), l.-p.	1/16-in.	.....

Miscellaneous:

Exhaust nozzle, diameter	5 ins.	5½, 5¾, 6 ins.
To center of boiler	7 ins. below.	6¾ ins. below
Smokestack, diam at top	1 ft. 5½ ins.	1 ft. 3⅝ ins.
Diameter at base	1 " 3½ "	.....
Height abv smokebox	3 " 0 "	2 ft. 3 ins.
Height above rail	15 " 4 "	15 " 6 "
Oil	2,200 galls.	2,250 galls.
Water	6,000 "	7,000 "

*The Baldwin decapod engines will have blind tires on the third pair of drivers.
†At half stroke.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

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D. McN. STAUFFER, - - - - - - - VICE-PRESIDENT.
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PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
CLEVELAND OFFICE, OSBORN BUILDING.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.60 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current Volume, 15 cents.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

A new wrinkle in painting structural steel exposed to locomotive gases is described in the paper by Mr. Geo. W. Lilly, of Columbus, O., printed in this issue. It consists in plastering the metal with a coating composed of Portland cement, red lead and linseed oil, the coat applied being about ¼-in. thick and being laid on with a trowel. While the cost given (8 cts. per sq. ft.) is considerable, it is certainly cheaper than frequent repaintings which do not after all furnish efficient protection to steel so exposed. If this coating will adhere permanently to the metal—and we understand it has gone through two winters and summers already—it may furnish a solution for the difficult problem of protecting steel viaducts over railway tracks from rapid destruction.

We commented in our issue of Feb. 20 on the advertisement of the Sanitary District of Chicago inviting bids for furnishing "harness" for the water power plant at Lockport, this "harness" consisting not of leather and buckles but of machinery to transmit the power from the turbines to the generators. Apparently the makers of such machinery did not understand that they were in the "harness" business, for when the bids were opened there were no bids to open! A new call for bids has therefore been prepared and is printed elsewhere in this issue. We trust it may be understood this time that the appeal is to followers of Vulcan and not to those of St. Crispin.

The curious old scheme for modifying the climate of the Canadian maritime provinces by building an embankment across the Straits of Belle Isle is again heard from in the newspapers. The New York "Sun" of April 18 states that the project is under consideration in Quebec. The straits are about 10 miles wide at their narrowest part, and the maximum depth is said to be 180 ft. Given time enough and money enough, of course an embankment could be built across the strait; but the benefits to be derived would seem far too uncertain to permit the investment of either private capital or government funds in such a work. The promoters claim that vast quantities of ice pass through the straits, together with a branch of the Arctic current, and reduce the temperature of the entire country surrounding St. Lawrence Bay to a level far below what it would be under normal conditions. It seems probable, however, that even if the strait were closed the cold Arctic current, filling all the adjacent seas and swinging around to the east of Newfoundland, would keep the climate practically the same as at present.

We noted in our issue of March 27 a fatal disaster investigated by the British Board of Trade, in which the cause was the blowing out of the gasket around a boiler manhole. In New York city, on April 15, a fireman was fatally scalded by the blowing out of a gasket on a steam pipe connected to a small boiler of only 16 HP. A chain is no stronger than its weakest link and a steam pipe is no stronger than its weakest point. The use of gaskets in making steam joints ought to be dispensed with wherever possible, and where their use is unavoidable, the joint should be so designed that the packing cannot blow out. Attention to small details like these is quite as essential to safety as care for what are commonly considered the more important features of the design.

"EXPERT" LIARS.

A recent Boston damage case, necessitating the testimony of experts as to values, brought out estimates by real estate experts ranging from nothing to $10,000 on one side, and from $78,000 to $98,000 on the other. As the "Boston Daily Advertiser" remarks, in commenting on the case, "somebody must have been mistaken!" and the term "expert liar" is applied to these mistaken somebodies. The courts consider so-called expert testimony as an expression of opinion upon some matter about which the general public is supposed to be more or less ignorant. As regarded by the law, perjury is a misstatement of actual facts; while a man is not guilty of perjury for testifying as to his opinion, no matter how mistaken he may be.

The whole trouble lies in the method allowed by the courts in setting before it and the jury the opinions of men supposed to have special knowledge upon special subjects. The men giving these opinions are now selected by the opposing sides to the controversy; and each expert is actually as much an advocate as is the lawyer himself. He is practically retained by his client—the lawyer—to find in the case what will nearest meet the purposes of that lawyer. He cannot act in a perfectly free, judicial capacity, under controlling conditions. His answer is blocked-out for him beforehand; and it is his "business" to so twist the facts that they will appear to favor his client. The more able and experienced the expert, the more dangerous he is under existing practice; for he is by so much the better able to brush aside the testimony of the experts of the other side, and to befog judge, lawyers and jury by his learning and special knowledge. Under the law he cannot be punished for his "opinion"; but a gross injustice may be done to the client not so fortunate in his selection of an expert.

The outcome of all this is that expert testimony from any source is being less and less respected in the cases before our courts. The judges generally understand the biased character of expert evidence and seek for information from some source outside the realm of expert testimony upon which to base their own decisions. This condition is unfortunate, because in many cases before the courts special knowledge is badly needed in the proper adjustment of values, controlling conditions, relations, etc., and without this instruction to judge and jury an intelligent opinion is almost impossible. It is useless to admit, as some suggest, only expert testimony upon facts. For while the law could punish misstatement of facts, it would require another set of experts to make clear to the layman how those facts were misstated, and which of the expert assortment of "facts" were actually facts and which were not.

It has been suggested before, and it still seems to be the only way out of the difficulty, to have the court appoint the experts independently of the interests of either party. It would then be the business of the court to select a jury of experts, whose sole duty it would be to render an opinion based wholly upon the real facts in the cause and upon their combined experience. This is now the practice of all large business interests having to decide upon the respective merits of several or many technical plans placed before them for adoption. The president and directors—or the judge and jury in this case—realize that they are without the special training fitting them to decide, and so they call in acknowledged experts to decide for them. This is common practice; and the vast sums of money annually expended upon the judgment of experts of this class attest to the well-merited confidence reposed in their opinions and the general wisdom of the policy adopted.

The objection made to this policy in court trials is that no court would pay the fees that a client would award, and that "cheap experts" would be the rule. But even better cheap experts than warped justice; and justice becomes a farce when its award is based largely upon the sum an interested party can afford to pay for expert testimony. The law could probably find a way, however, for commanding intelligent and sufficient expert evidence, for a reasonable compensation, just as it can now command the presence of any necessary witness with little or no fee at all. It is a case for the makers of the law to settle; and it is time that it was settled, for the whole present system of expert-opinion evidence has fallen to a low plane.

CONCERNING THE SELECTION OF MATTER FOR PUBLICATION IN ENGINEERING NEWS.

Not a day passes but there come to this office letters which indicate a large misunderstanding on the part of the writers as to the policy of this journal respecting the selection of matter for publication. There is a great and amusing variety in these letters. Some offer to pay cash for the publication of an article. Others offer "trade-write-ups," so-called, and ask that they be inserted in return for advertising patronage, present or prospective. Others who offer contributions appear to think that an introduction from a personal acquaintance of some member of the editorial staff is necessary, in order that their contributions shall receive attention.

So many of these evidences of misunderstanding as to the policy of this journal have come to us that we have thought it worth while to formulate the following general statement:

I.

The selection of all matter for publication in the reading matter pages of Engineering News is made solely on the basis of its interest and value to the readers. This journal has no "deadhead" list. Its subscribers pay five dollars a year for their paper and are entitled to receive the best matter that the editors can select. To make this selection on any other ground than the readers' interest—to publish this article to please a personal friend, that to please an advertising patron, the other for some form of payment, direct or indirect—is essentially to defraud the subscriber.

The article which is chosen for such ulterior reasons might be in itself comparatively harmless; it might be so well written that not one reader in a thousand would notice it to be below the standard usually maintained in this journal; yet if the principle is once established that articles may be selected for publication for other reasons than their actual value to the reader, the road downhill is an easy one. If one advertiser is given a "trade-write-up," another must have a "reading notice." It is a short step from that to the direct sale of space in the reading matter pages as part of an advertising contract, and another short step to the publication of paid

puffs to help one competitor and paid blackmailing articles to injure another.

This is the reason why our rule that the readers' interest, and that alone, must govern in the selection of articles is rigidly maintained.

II.

A very large part of the important and interesting engineering work of the present day is being done in connection with manufacturing establishments. The published description of this work may be and often is an exceedingly valuable advertisement for the parties interested. This fact, as stated above, is no reason why we should give space to it in Engineering News; but, on the other hand, it is no reason why we should exclude it. What we are after is what will interest our readers. If the publication of an article benefits somebody or other as an advertisement, so much the better.

The editors of Engineering News, therefore, receive and examine with great care matter submitted by manufacturers, advertisers, and others descriptive of new devices, machinery, tools, plant and methods of doing work, and selection is made from this matter solely on the basis of what the editors believe to be the interest of the readers. Thus the "trade-write-up" is judged on the same basis as the original contribution of a practising engineer, or the paper read before an engineering society. The better the article which the manufacturer submits, the better its chances of acceptance. It must be remembered that the amount of matter offered to the editors, and from which they must make their choice is many times as great as the pages of Engineering News can contain. Obviously a great deal of matter has to be rejected, not because it is not good, but because it does not rank among the best.

III.

The conditions of publication are often of importance in determining the acceptance or rejection of an article. The "trade-write-up" which is sent out broadcast to all sorts of trade journals is pretty sure of rejection. That which is sent out for simultaneous publication in a limited list of papers stands a little better chance, but if accepted it will generally be given briefer space than it would receive were we given the first opportunity of publication, or were the article given to us exclusively.

IV.

Not only for the sake of securing its acceptance, but for the sake of holding the interests of the largest number of our readers, it is worth while to take much pains in the preparation of matter to be offered to Engineering News. Where matter is to be submitted by a manufacturing establishment we would counsel its preparation by the engineering department rather than the advertising department. What we want, and what our readers want, is not "glittering generalities" but plain statements by the practical men of how engineering problems have been solved. For illustrations, we prefer drawings or blue-prints and good photographs, from which we can prepare our own cuts.

V.

Final decision as to whether an article offered to us will be accepted, cannot be made until the completed article is placed in our hands. We will give an opinion, however, on request, as to the probabilities of an article on a stated subject being acceptable. Matter found unavailable for use will be returned, if return is requested.

VI.

As a rule, new inventions, machines, etc., are not described until they have been actually built and practically operated. Exception to this rule is made only in case a device is of unusual interest and is of such a character that its merits can be fairly judged from the description and drawing. It may be added that this rule works to the benefit of the inventor. It is a mistake to rush into print with the description of a device until it has actually taken concrete form, and until actual experience can be quoted in support of the claims made for it.

VII.

We pay cash for original contributions to Engineering News. Articles prepared by our own staff on the basis of information furnished by manufacturers are of course not paid for, under ordinary circumstances. No articles are paid for unless furnished exclusively to us, and in the submission of matter by manufacturers it should be explicitly stated whether any prior publication has been made, and, if, so, where (mention in trade catalogues should not be omitted). It should also be stated whether exclusive publication is offered to us or whether the matter is to be given to other journals, with full particulars.

VIII.

The editors lay no claim to infallibility of judgment or infinite knowledge. They may often err in their selection of matter by accepting the poorer and rejecting the better. Moreover, they have to be governed by conditions of which the outsider knows nothing. Available space and current interest in a particular line may often cause the acceptance of an article which is in other respects not so good as other articles which meet with refusal. The demands on the time of the editors are such that they cannot undertake to state in detail the reasons which govern their decision to accept or reject any article.

LETTERS TO THE EDITOR.

Grasses as Sand and Soil-Binders.

Sir: Along the southern shore of Nova Scotia there are a number of valuable beaches built up of white hard sand which have, at or slightly above high water mark, mounds of sand from 6 to 9 ft. in height and which generally protect either valuable lands or small creeks or harbors from the inroads of the heavier seas of the Atlantic. In stormy seasons these mounds are often damaged, and in some cases have been destroyed, whilst in others they have been gradually forced landwards, thus encroaching upon these lands and harbors. Several plans for protecting these beaches have been tried, but with doubtful success; for shifting sand is not the best foundation for protection works. I have noticed that when a storm does damage to these mounds it breaks through in gaps and leaves isolated portions along the whole length of these beaches apparently unharmed. Upon examination, or, rather, observation, it is found that those portions unharmed are covered by a sward formed of roots of a rank and broad-leafed grass. I would therefore request you to inform me whether the seed for this or similar vegetation could not be procured, and, if so, where? If a sward of this nature could be fostered, we could save our beaches and other valuable interests in this way. I believe the celebrated Goodwin sands have been experimented upon, and with much success, in this manner, but have no positive information. Yours sincerely,

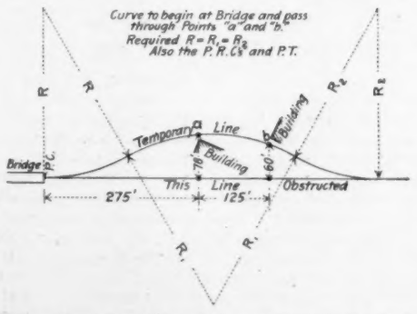
Thomas J. Locke.

Public Works of Canada, Resident Engineer's Office,
Halifax, Jan. 22, 1902.

(We answer this letter elsewhere in this issue.—Ed.)

A Problem in Laying Out Reversed Curves.

Sir: In looking over my Engineering News for 1901, I notice some discussion in the numbers for April 11 and May 30, which escaped my attention at the time, regarding the determination of the radii of reversed curves connecting tangents not parallel. I therefore call your attention to a curve problem which I encountered in some railroad work a few years ago, which, although not between non-parallel tangents, is not easy of solution at first sight.



It was necessary to build a temporary track around certain obstructions; the beginning of the curve being determined by a bridge, and two other points on the reversed curves being determined by clearances from buildings, as indicated by the diagram herewith. It was desirable to have the curves of equal radii because it was evident that the curvature was about the maximum that the engines that were to use the track would go around; but as it was temporary work and wanted at once, I staked the curves out with approximately equal radii, by trial, and have not taken the time since to try to find a rational solution for the problem.

If you think it would interest your readers, I should be glad to have you present it to them. Yours truly,

E. N. Layfield.

Chicago, Ill., April 10, 1902.

Suggestions Regarding the Reconstruction of the Austin Dam.

Sir: I notice another article in the Engineering News of April 3, containing a new section and some advice regarding the rebuilding of the dam at Austin, Tex.

As a Texian, I am or should be privileged to make a few remarks on this subject, especially now as there is a chance that the dam will be rebuilt. I visited the wrecked dam in April of 1900 for the benefit of some Chicago people, who intended building a similar structure for electric power in the State of Chihuahua, Mex. After calling on Mr. T. U. Taylor, Professor of Engineering at the State University, who gave me all the information in his power, I went out to the dam and made as close an examination as the short time and the means I had at hand would permit. From what I saw there I concluded that the cut-stone back and face on the dam was a waste of money. I believe if the dam had been built entirely of third-class or rubble masonry, well bonded, and the stone thoroughly bedded in cement mortar, it would have been far stronger than with the cut-stone facing. An examination of the broken sections exposed showed spaces or cracks from the width of a knife blade to half an inch between the cut stone and the rubble. The rubble or core was very badly constructed; there seemed to have been no care taken, or effort made, to bed the stone in mortar. I saw a number of places, as large as a square foot, that contained nothing but dry stone. Whether this was the cause of the masonry contracting and causing the above-mentioned crack between core and face, or whether the masonry would not have contracted any way, after it had dried out, I leave to wiser heads than mine to answer, but this I will say, had the dam been built of one homogeneous mass of third-class or rubble masonry, well bonded, it would have been stronger than the same section with the cut-stone facing. This would also have saved a large percentage of the cost, as there is a large difference in the cost of masonry where the price of cut stone is $15 per cu. yd. and rubble is $3.50.

I also think it would be a mistake to rebuild the dam without allowing for an outlet or spillway beneath it. I think that the soft mud or silt pressing against the face did more than any other one thing to cause the failure. This silt probably weighed nearly double as much as clear water and after settling a few hours, at least 100 lbs. per cu. ft. The dam was not designed to withstand this load.

With a 6-ft. circular arch at the bottom, resting on bed-rock and running under the dam at its deepest point, and with a head-gate that could be raised or lowered from the top of the dam, this danger could be avoided, besides a large portion of the silt would be washed away and would not have to be removed by hand. This is a good reason in itself for building the arch. Therefore I advocate:

(1) That the dam be built of rubble masonry with cement mortar.

(2) That a waste culvert be built beneath it.

(3) That the present structure be torn out and the stone used over if built in the same place.

(4) That the foundation be deepened and widened where the rupture occurred.

(5) Last and most important, that the entire work be placed in hands of a board of practical men who can see the necessity of getting the very best engineering ability to take and keep charge of the work, and that no man holding political office be allowed to have anything to do with it. Respectfully,

G. A. Stranahan,
Resident Engineer, Mexican Central Railway.

City of Mexico, Mex., April 12, 1902.

Moving Load Shears in Trusses with Parallel Chords.

Sir: The method of finding moving load shears in trusses with parallel chords, given by Mr. H. E. Vautelet as original, in your issue of April 10, is the same method given in "Modern Framed Structures," p. 51 (Eq. 17a). The equations given in this work are of more ready application than those given by your correspondent, but the method of derivation and the final equations are identical.

J. B. Johnson, College of Mechanics and Engineering,
University of Wisconsin.

Madison, Wis., April 15, 1902.

Sir: In your issue of April 10 you published a letter from Mr. H. E. Vautelet, deriving a method of obtaining the maximum web stresses in trusses with parallel chords, for uniformly distributed moving loads. The criterion which your correspondent derives is a special statement of the usual criterion for maximum shear in such trusses, namely: a maximum shear occurs in any panel when

the load in that panel divided by the panel length is equal to the total load on the span divided by the span length.

The letter referred to gives the derivation of the following equation for maximum shear:

$$(R - r)_{max} = \frac{p\,M^2}{2\,(L - l)}$$

in which R is the reaction at the left abutment, r the panel concentration at the left of the panel in question, p the load per unit of length on the span, M the distance from the right abutment to the right-hand limit of the panel in question, L the span length and l the panel length.

If now we let N be the total number of panels and n the number to the right of the panel in question, we have

$$L = l\,N \quad \text{and} \quad M = l\,n.$$

Calling the shear $S = (R - r)$ and substituting we get

$$S_{max} = \frac{p\,l^2\,n^2}{2\,(l\,N - l)},$$

or,

$$S_{max} = p\,l\,\frac{n^2}{2\,(N - 1)}.$$

It will be seen that the fractional factor in this formula varies, not with the span length, but with the number of panels. Therefore in ordinary practice it can have but few values. These may be tabulated and used as coefficients of the quantity pl in the calculation of all such trusses, subject to various uniform rolling loads.

Following is such a table for spans of from five to ten panels.

Values of Coefficient of pl.

No. of panels in span..	5	6	7	8	9	10
1st panel.....	2.0	2.5	3.0	3.5	4.0	4.5
2d "	1.125	1.6	2.083	2.571	3.063	3.556
3d "	0.5	0.9	1.333	1.785	2.25	2.723
4th "	0.125	0.4	0.75	1.142	1.563	2.0
5th "	...	0.1	0.333	0.643	1.0	1.389
6th "	...	...	0.083	0.286	0.563	0.889
7th "	...	...	...	0.071	0.25	0.5
8th "	...	...	...	...	0.063	0.222
9th "	...	...	...	...	...	0.056

In computing a truss with this table, the quantity pl is a common factor for the shears in all panels, so that a single setting of the slide rule gives all of the shears, and a second setting, using the secant, gives the stresses in the diagonals.

The above formula and table, originally derived somewhat differently by the writer, have been the means of saving some time and mental energy. It is not offered as a novelty, but because there may be some who can profit by it or suggest an improvement on it. Yours truly,

P. E. Stevens, Assoc. Mem. Am. Soc. C. E.

1810 Diamond St., Philadelphia, Pa., April 12, 1902.

Sir: Referring to the communication of Mr. H. E. Vautelet concerning "Moving Load Shears in Trusses with Parallel Chords," in your issue of April 10th, in which Mr. Vautelet develops a rational expression for the distance that a uniform moving load should extend into a panel of a parallel chord bridge in order to give the maximum shear in that panel, and in which he further points out that this maximum shear is the same as that in a similar truss with one less panel when the load is not assumed to extend into the panel at all, it is not clear whether Mr. Vautelet offers as the novelty the rational expression for the proper position of the end of the moving uniform load, or the identity of shears in the two different trusses. If the former, it may be said that the principle has been taught in American engineering schools for at least sixteen years past and its development is given in the more important works on bridge stresses and designing. If the latter, Mr. Vautelet will find the identity of the two shears pointed out by, or at least readily inferred from, a comparison which Johnson draws, in his "Theory and Practice of Modern Framed Structures," page 51, between two expressions representing the shear by the exact method followed by Mr. Vautelet and the usual approximate method of assuming only full-panel loads; the expression representing the true exact shear becomes identical with the other if in place of n the number of panels (n — 1) be substituted.

Johnson also develops on page 63 a general expression for the distance the uniform load must extend into the panel of *any* bridge, whether with parallel or non-parallel chords, in order to produce the exact maximum shear, and shows that the general form reduces to the previous special form by making the chords parallel.

Mr. Vautelet is doubtless entitled to the originality of factoring the final expression for the true maximum shear into the two terms he offers, one of which expresses the end-shear in another truss equal in length to the loaded panels of the given truss, but the advantage claimed for the solution of these two terms over the unfactored expression is not apparent.

It is hardly necessary to say that in general the method of determining the exact shears from the true position of the end of the uniform moving load is unnecessary even though but slightly more troublesome than the approximate method of assumed full-panel loads, for the approximate method gives shears whose errors are on the side of safety and never amount to so much as one-eighth of one panel load and vary from the maximum value down to zero. When greater precision than this is demanded it will be necessary to take the actual load concentrations in place of the assumed uniform loads, which latter rarely if ever occur in practice.

Olin H. Landreth.

Engineering School of Union College,
Schenectady, N. Y., April 12, 1902.

The Fire at the Works of the Pacific Coast Borax Co., Bayonne, N. J.

Sir: In reference to the note on the above subject in your issue of April 10, I desire to make the following corrections and additions to your statements:

The building is in plan 250 ft. × 200 ft. and it is four stories high for over one-third of its depth. The foundations, walls, main columns, girders and floor are all reinforced concrete. The stairways, partitions, elevator shafts, bins, roof supports and roofs, also most of the framing for the machinery were of wood.

For the requirements of the business there were many holes through each floor. The height of the stories are 20 ft., 16 ft., 14 ft. and 12 ft. The columns are 21 ins. square, with a safe working load of about 70 tons per sq. ft.; crushing strength is 350 tons per sq. ft.

The girders span 12 ft. 6 ins. between centers of columns; the beams span 25 ft., c. to c.; the floor loads are nominally 500 lbs. per sq. ft. They have been loaded much heavier; in one case as high as 1,650 lbs. per sq. ft. This load covered an area of about 100 sq. ft. The foundations are spread foundations on the Ransome system.

The largest pieces of iron used in the structure are twisted steel bars 1½ ins. square. The fire was so severe that in many cases the outside copper fittings to the electric motors melted, and in two cases or more the cast-iron of the machinery was fused together so strongly that on breaking the mass the line of union in the several pieces could not be seen.

Over the roof several iron tanks and one steel dust collector were supported upon wooden framework which extended down to the fourth floor, 14 ft. below. During the fire, as the supports burned away, all these fell to the floor beneath. In a few instances the floor beams subjected to this shock cracked, but in no case did they fail to sustain the load. In only one case was the thickness of the floor (about 5 ins.) penetrated, and that was occasioned by the corner of a large tank partly filled falling 14 ft. and striking thereon. The dust collector, weighing over 30 tons, in falling fell in part upon some filled sacks which deadened the blow. Notwithstanding this the shock must have been very heavy, but no appreciable harm was done to the floor. On the fifth story a tank weighing 83 tons when full, as it was at the time of the fire, stands intact. The tank emptied after the fire had progressed for quite a time, by reason of the machinery falling and breaking the discharge pipe. Beyond the cracking of a few beams, one small hole punched in the floor and a little falling off of a thin scale of plaster of whitewash, the entire concrete structure is absolutely uninjured from fire. The structural steel framing used in support of some tanks completely collapsed.

The hollow walls, 200 ft. long, without any lateral support, remained intact and in as exact a line as when built. The concrete is as compact and as hard as ever; in one or two cases only the surface, to a depth of perhaps ⅝-in., has been disturbed. I attribute this remarkable showing to the use of the special solution which we add to our concrete mixtures and for which we claim the inventor's rights; letters patent have not yet been issued to us, and for this reason we prefer at present to keep it as a trade secret.

At the time that building was constructed had we used, as fully as we do now, the vertical U-bars in the concrete beams, I do not believe that a single beam would have cracked; as it is we are entirely satisfied with the magnificent showing this construction has made in so hot a fire.

Yours very truly,

Ernest L. Ransome.

11 Broadway, New York, April 15, 1902.

(The discrepancy between the dimensions given above and those given in our note is due to the fact that our note referred only to the main or four-story part of the building, while Mr. Ransome includes the shed extension. The latter is one-story high and contained a large number of open tanks; the walls are of concrete, while the roof and its supporting posts were of wood. The burning up of the latter presented no points of interest.

The four-story portion of the building, on the other hand, was, with the exception of roof, stairway, elevator shaft, etc., built entirely of concrete-steel on the Ransome system. The roof was of wood, as were also the elevator framing and enclosure, stairways, and some parts of the machinery; there was little other combustible matter in the building. The fire ran up the elevator shaft, consumed this latter, and set fire to the roof, which was also consumed. Little other damage was done by the fire itself. We see no reason to change our opinion, based on personal inspection, that the fire was at no time a "hot fire." As to the melting of copper, etc., which Mr. Ransome mentions, local concentrations of heat are so well known in all cases of fire that the statement can be regarded as of no weight. In one case, a department store fire, which was inspected by a representative of this paper, the iron bases of stools standing before a counter were destroyed, while the cloth on the top of the counter was hardly scorched.

Of far greater importance and interest than the question of whether the fire was or was not a severe test of the concrete construction (which is after all largely a matter of opinion) is the query likely to occur to the reader: Where such considerable expense was incurred to make the walls, floors and columns of the building thoroughly fireproof, why was the structure not made completely fireproof? Why were a wooden roof, wooden stairs, and above all, wooden elevator framing and enclosure put into the building? The additional cost of making these of some fireproof construction would have been insignificant, and the whole structure would then have been proof against any fire damage (more particularly since, as in the present case, the contents of the building offered no foothold to fire). As it was, these very points of neglect, small as they might seem, caused great loss, not only through the destruction of these combustible portions themselves, but to even greater extent in the damage to the contents of the building by water and by the general destruction and wrecking attendant upon any fire. This query, which occurs so naturally in the present instance, might, it will be found, be applied to a very large share of the "fireproof" structures already built or being built at present, and it merits much more serious and widespread attention than has been given it.—Ed.)

Notes and Queries.

The post office address is desired of Mr. Lionel M. Stern, of Cleveland, O., whose pamphlet on Paints for the Preservation of Metal was reviewed in our issue of March 6.

THE PREVENTION OF HAILSTORMS BY CANNON IN EUROPE.

In our issue of April 18, 1901, we abstracted a report on the above subject by the U. S. Consul at Lyons, France, and some editorial comments of the "Monthly Weather Review" upon that report. The January number of "Consular Reports" contains a further communication on this subject from Mr. H. H. Morgan, Consul at Aarau, Switzerland, which we reprint below. As appears from this report, the Italian work with the "hail cannon" has been so successful as to induce the Swiss government to consider taking up similar work on a large scale. It may be noted that the apparatus described in the present report is the same, or quite similar, to that described and illustrated in the article in our issue of April 18, 1901, above referred to.

Considerable interest is being manifested here in the action taken by the Swiss government looking toward the erection of bombarding stations in certain parts of the country for the prevention of the destructive hailstorms which at times have devastated entire districts.

The government in the first instance appointed Colonel Stahel and Mr. Girsberger to proceed to Italy and Styria to study the question and see what results had been achieved in these countries, where bombarding stations have for some time been in operation. These gentlemen have made a long and detailed report to the government, recommending the adoption of one of the systems in practice, and from the report the following has been extracted:

The classical land of hail shooting is Styria. The vine-growers there suffered so frequently and disastrously from hailstorms that they were forced to devise all sorts of means of protection; wires were stretched over the vineyards, and, when danger was anticipated, these were covered with cloth, planks, etc.—wearisome work, indeed. Ordinary small mortar guns were occasionally fired against the clouds in order to dispel them. Burgomaster Stieger, of Windisch-Feistritz, in Styria, took up the matter in a thorough and successful way and is to-day acknowledged by all those interested in hail shooting to be the originator and master of shooting as a means of protection against hailstorms. From Styria hail shooting spread over Hungary and Northern Italy, where at the present time more than 10,000 shooting stations are established. It appears that warm, marshy countries with broad rivers show the greatest interest in the means of protection against hailstorms, which may lead to the conclusion that such countries are more than others subject to hail. This, again, confirms the experience that

warm layers of air saturated with moisture, rising from damp, low countries, will turn into dangerous hail clouds when they meet a cold air current in the higher regions of atmosphere.

The principal part of the gun is a vertical mortar 8 to 11 ins. long, with a caliber of about 1½ ins. To the mortar is attached a conical funnel of a length of 7½ to 12 ft., the upper part of which projects from the top of the house. The supply of gunpowder ought to be kept well sealed in tins, divided into charges of 80 to 100 grams, and there should be a sufficient quantity for 50 shots for each gun. The stations are distributed over the danger district 1,200 to 1,800 ft. apart. Thus one station will protect about 62 acres. Upon an alarm being given all guns in the district should start firing, giving one shot each minute. Quicker firing is said to be less effective, as the shots would not have time to take full effect.

After firing a shot, a white ring will be seen rising from the funnel, gradually increasing in size to the diameter of 9 to 12 ft. Its force is sufficient to break wood sticks on its way, and if it hits at a distance of 300 ft. or more a target made of coarse hurdlework it cuts out a ring, leaving the center and the circumference unhurt. The effect of the air ring shot into the hail clouds is not sufficiently explained, but it disturbs their natural course of dangerous development.

Upon this report, a commission has been named, which will adopt regulations for the service. The regulations propose the forming of societies in all the interested districts.

TESTS OF MORTAR MADE OF CEMENT AND LIMESTONE SCREENINGS.

The report on the highways of Maryland, just issued by the Highway Division of the Maryland Geological Survey, is largely devoted to testing machines and the results of tests of paving brick, cements and macadam material.

Among the more interesting tests is a series made to determine the relative strengths of cement mortars made of different proportions of cement and sand, cement and limestone screenings, and cement, sand and limestone screenings. These tests were made at the request of Mr. Willard C. Keller, a contractor for cement pavements, of Frederick, Md., and they had for their object the determination of the influence of the sand and limestone screenings, respectively, upon the strength of the mortar. The cement used in the test was Dyckerhoff German Portland; the sand came from the Potomac River, and the screenings came from Frederick County limestone. The tests for strength were made after the briquettes had been exposed one day in the air and six days in water. The results obtained for the seven-day tests were as follows:

Proportions by weight of—			
Cement.	Limestone screenings.	Potomac River sand.	Strength in lbs. per sq. in.
1	0	0	493
1	1	0	291
1	0	1	217
1	2	0	208
1	0	2	129
1	3	0	157
1	0	3	108
1	1	1	209

The densities of the materials were determined by dropping them from a height of 3 ft., and leveling the top of the box with a straight edge; the contents of the box were then weighed and the densities were found to be—sand, 1.60; cement, 1.54, and screenings, 1.51. The results in the above table would have been practically the same had the proportions been by volume instead of weight. The table shows the average for a number of tests in each case.

The pure cement is stronger than any of the mixtures; but the mortars made with limestone are stronger than those made with sand. The report gives two reasons for this. First, owing to the lime in the cement there is probably a much closer cohesion with the limestone screenings than with the quartz sand. Second, the limestone screenings used in this test are composed of finer particles than the sand, as is shown by the fact that 70% of the limestone screenings and 92% of the sand were stopped by a sieve of 50 meshes to the inch; while 83% of the screenings and 99% of the sand were stopped by a sieve of 100 meshes to the inch; 90% of the Portland cement passed through the latter sieve.

The deduction to be made from this report is that some specifications entail needless expense in directing that all dust be taken out of broken limestone used in concrete. In connection with its affinity for the cement itself the limestone dust better fills the voids in the cement mortar, and a stronger and more homogeneous concrete is the result.

CARBONATE OF SODA IN MORTARS USED IN FREEZING WEATHER.

In building water-power stations on a Swiss electric railway from Fayet to Chamonix, it was necessary to build masonry in cold weather; and the results of experiments with mortars mixed with carbonate of soda are set forth in the "Revue Generale des Chemins de Fer," for March, 1902.

A solution of carbonate of soda was used in treating three grades of mortar, having the following compositions:

No. 1, 300 kg. of hydraulic lime, 0.90 cu. m. of sand.

No. 2, 300 kg. of hydraulic lime; 150 kg. Vicat cement; 0.90 cu. m. sand.

No. 3, 400 kg. Vicat cement; 0.90 cu. m. sand.

The carbonate of soda used was that known in commerce as the hydrate. The proportions used varied from 8 to 20 kg. per 100 liters of water; the latter proportion being employed when the temperature fell below 8° C. The soda solution was prepared in a kettle and kept at 50° to 60° C., a temperature sufficient to insure the entire dissolving of the salt. Some masonry laid with mortar No. 2 contained 8 kg. of carbonate of soda to the 100 liters of water; and when this mortar was used at temperatures of — 2° to — 12° C. very good results were secured.

Four trial briquettes of ordinary dimensions were made with the following mortars:

No. 1. With No. 1 mortar and no soda.

No. 2. With No. 1 mortar and 8 kg. of soda to 100 liters of water.

No. 3. With No. 2 mortar and no soda.

No. 4. With No. 2 mortar and 8 kg. soda to 100 liters water.

These four briquettes were made in November, 1900, and were exposed during the winter, without any protection, to temperatures as low as — 30° C. In March, 1901, these bricks accidentally fell from a height of 45 m., or 147.6 ft. An examination of the fallen bricks showed that Brick No. 4 had resisted the shock and was only slightly broken at the corners. Bricks Nos. 1, 2 and 3 were broken into fragments; but while Nos. 2 and 3 presented a certain consistency in the fragments, No. 1 crushed under the pressure of the hand.

In another experiment two test-blocks made with mortar No. 3, one with and the other without soda, were submitted to a temperature of — 18° C.; and for some days to —30° C. After the spring thaw these samples were examined, and the one made of the soda-mortar was solid, while the other disintegrated easily. The experimenters conclude by saying that while the tests indicate that carbonate of soda can be used in exceptional work performed in the winter season, work executed under these conditions demands the greatest care.

THE CHEMISTRY OF THE PROTECTION OF STEEL AGAINST RUST AND FIRE BY CONCRETE.

The newspapers have commented with considerable alarm upon the prediction recently made by Gen. Wm. Sooy Smith, M. Am. Soc. C. E., of Chicago, that the modern steel skeleton building would prove to be a short-lived structure owing to the inadequacy of a covering of concrete to protect the steel from rust. Among engineers it has been considered generally that no more efficient a protective covering for steel than concrete could be had. All past experience has supported this belief, which is based, besides, on chemical and physical laws that have at least sound reasoning as their foundation. These laws have recently been summarized by Prof. Spencer B. Newberry,* and in view of the wide interest attracted by Gen. Smith's alarming prediction, we quote the portions of this summary which bear most directly upon the question raised by that well-known Chicago engineer:

There are two important respects in which steel construction gains by the addition of concrete. These are protection against rust and protection against injury by fire. Leaving the engineering aspects of the question to those far more competent to discuss them, I ask your attention for a few minutes to a brief consideration of the chemical and physical laws by which this protection from rust and fire is assured.

The rusting of iron consists in oxidation of the metal to the condition of hydrated oxide. It does not take place at ordinary temperatures, in dry air, or in moist air free from carbonic acid. The combined action of moisture and carbonic acid is necessary. Ferrous carbonate is first formed; this is at once oxidized to ferric oxide, and the liberated carbon dioxide acts on a fresh portion of metal. Once started, the corrosion proceeds rapidly, perhaps on account of galvanic action between the oxide and the metal. Water holding carbonic acid in solution, even if free from oxygen, acts as an acid, and rapidly attacks iron. In lime water or soda solution the metal remains bright. The action of cement in preventing rust is now apparent. Portland cement contains about 63% lime. By the action of water it is converted into a crystalline mass of hydrated calcium silicate and calcium hydrate. In hardening it rapidly absorbs carbonic acid and becomes coated on the surface with a film of carbonate. Cement mortar thus acts as an efficient protector of iron, and captures and imprisons every carbonic acid molecule that threatens to attack the metal. The action is therefore not due to the exclusion of air, and even though the concrete be porous, and not in contact with the metal at all points, it will still filter out and neutralize the acid and prevent its corrosive effect.

Opportunity to determine the condition of steel imbedded in concrete after years of exposure to air and moisture is seldom obtained. In all cases, however, in which such work has been taken up and examined the metal has been found bright and free from corrosion, and all who have witnessed the tests agree that the preservation of the steel is remarkable. A striking example of this is found in the inspection of a cement and steel water main on the Monier system at Grenoble, France. This main was laid in 1886, and consisted of cement pipes of 12 ins. inside diameter, 1 3-5 ins. thick, containing a steel framework formed of 30 ¼-in. rods surrounded by an outer spiral ¼-in. and enclosing an inner spiral 1-6-in. in diameter. The spirals and rods were bound together by knots of iron wire. On Feb. 2, 1901, three lengths of this pipe, which had lain 15 years in damp ground, were taken up in the presence of a number of officials and engineers, who certified to the results of the inspection. The tubes showed no cracks, and the adhesion of the cement mortar to the iron was so firm that it could be loosened only by strong hammering; on striking with a heavy hammer the tubes gave out a musical tone like cast-iron. The metal showed no trace of oxidation; even the wire knots were absolutely free from rust.

On March 13, 1901, the Prussian Minister of Public Works investigated the condition of the concrete-steel retaining wall on the Oberstrasse, Berlin, built in 1890. On breaking away the concrete at many points the iron was found entirely free from corrosion.

In No. 7 of "Expanded Metal Doings" is to be found the testimony of a large number of American engineers and architects as to the results of their inspection of steel after several years' protection by concrete. All agree that the preservation of the metal is most satisfactory. Mr. James Christie, of the Pencoyd Iron Works, reports as follows:

We have had several opportunities to examine iron that had been imbedded in cement concrete for periods varying from five to ten years. I have never seen a case where any appearance of corrosion existed. In fact, the preservative effect was always in evidence. In one instance the bases of angle iron posts were in a situation damp and slightly acidulated. These were effectually protected by a casing of cement. . . . We have recently applied a wash coat of cement to exposed surfaces of girders. I will let you know the result after some time has elapsed.

Regarding the use of Portland cement as paint for iron work, the following notes may be of interest:

According to "La Revue Technique," cement paint is largely used by the railway companies of France to protect the iron work of bridges from rust and corrosion of steam and sulphurous gases from locomotives. The iron is brushed with leather brooms, dampened, and given two coats of liquid cement and sand.

At Zeebrugge, in Belgium, steel piles are cleaned by sand-blast and coated with semi-fluid cement mortar applied by compressed air.

In a discussion on concrete-steel construction before the American Society of Civil Engineers, June, 1898, Mr. Corydon T. Purdy stated that the engineers of the Boston Subway, after investigation and careful tests, adopted Portland cement paint for the protection of the steel beams of the structure.

Dr. Goslich, at the 1901 meeting of the German Portland Cement Manufacturers' Association, stated that iron spirit tanks, painted on the inside with Portland cement, are universally employed in European distilleries. The adhesion is increased by allowing the metal to become rusty before applying the cement paint, and perfect protection from further rusting is secured. Cement plastering is also largely used in this country to protect the inner surface of steel salt-pans and sulphite digesters from the corrosive action of the hot solutions with which they are filled. In the same way that Portland cement, from its alkaline nature, neutralizes and fixes carbonic acid, so it protects iron from the attacks of other dilute acids, such as the sul-

*A paper read before the annual meeting of the Associated Expanded Metal Companies at Chicago, Ill., Feb. 20, 1902.

phurous and sulphuric acid contained in the products of combustion of coal. The fear has sometimes been expressed that cinder concrete would prove injurious to iron, on account of the sulphur contained in the cinders. The amount of this sulphur is, however, extremely small. Not finding any definite figures on this point, I determined the sulphur contained in an average sample of cinders from Pittsburg coal. The coal in its raw state contains rather a high percentage of sulphur, about 1.5%. The cinders proved to contain only 0.61% sulphur. This amount is quite insignificant, and even if all oxidized to sulphuric acid it would at once be taken up and neutralized in concrete by the cement present, and could by no possibility attack the iron.

These considerations and examples show clearly that no anxiety need be felt in regard to the durability of steel imbedded in concrete, even when exposed to the most trying conditions that can occur in practice.

The fire-resisting qualities of cement may be said to be a comparatively new discovery, one of the many unexpected practical applications of this valuable material which the past few years have revealed. It is well known that Portland cement is practically infusible, and that the water with which it combines in hardening is given off very slowly under the action of heat. The surprising feature of its behavior when strongly heated is that it does not crumble, crack, warp or scale off, as most other materials do. Even after long calcination at high temperature it still shows considerable cohesion and adhesion to metal, resists the impact of powerful streams of water, and does not crack under sudden cooling. On moistening with water after ignition it again hardens. Even if this last property be found unavailable for practical purposes, yet concrete exposed to fire and water is easily replaced, and its purpose is fulfilled if it protects from injury the steel work upon which the safety of the building depends.

The two principal sources from which cement concrete derives its capacity to resist fire and prevent its transference to steel are its combined water and porosity. Portland cement takes up in hardening a variable amount of water, depending on surrounding conditions. In a dense briquette of neat cement the combined water may reach 12%. A mixture of cement with three parts sand will take up water to the amount of about 18% of the cement contained. This water is chemically combined, and not given off at the boiling point. On heating, a part of the water goes off at about 500° F., but the dehydration is not complete until 900° F. is reached. This vaporization of water absorbs heat, and keeps the mass for a long time at comparatively low temperature. A steel beam or column imbedded in concrete is thus cooled by the volatilization of water in the surrounding cement. The principle is the same as in the use of crystallized alum in the casings of fireproof safes; natural hydraulic cement is largely used in safes for the same purpose.

The porosity of concrete also offers great resistance to the passage of heat. Air is a poor conductor, and it is well known that an air space is a most efficient protection against conduction. Porous substances, such as asbestos, mineral wool, etc., are always used as heat insulating material. For the same reason cinder concrete, being highly porous, is a much better non-conductor than a dense concrete made of sand and gravel or stone, and has the added advantage of lightness. In a fire the outside of the concrete may reach a high temperature, but the heat only slowly and imperfectly penetrates the mass, and reaches the steel so gradually that it is carried off by the metal as fast as it is supplied.

The thickness of concrete required to prevent injury to metal structures is more or less a matter of conjecture, based on observation of the results of fires. Mr. Wm. Parker, in a discussion before the American Society of Civil Engineers, June 26, 1901, states that practically no experiments on this point are on record. In his opinion the maximum depth to which concrete is liable to injury in fire is 1½ ins., and this only in case of very intense heat and impact of powerful streams of water. A depth of 2 ins. he considers sufficient to insure against possible serious injury. There is great need of careful experiments to determine the temperatures reached by steel beams protected by concrete coatings of varying thickness, and exposed for varying periods to heat of measured intensity. Such experiments could be carried out with little difficulty, and would form the basis for the establishment of exact rules for safe practice which would guarantee the protection of steel structures from temperatures liable to cause warping or undue strains due to expansion.

MOVING A LARGE BRIDGE OVER THE ALLEGHENY RIVER.

We noted briefly in our last issue (p. 301) the removal of the Allegheny River bridge of the Pittsburg, Fort Wayne & Chicago Ry. Herewith we present two views taken during the progress of the work. As there seen, cribwork extensions of the masonry piers were built on the down-stream side. The bridge spans were jacked up from their seats and rails were laid on the top of the piers and their cribwork extensions. Steel rollers were interposed between these rails and the beams on which the end shoes were supported. Three hoisting engines furnished the power for the moving, the several spools being connected to the track so as to haul steadily. In this way the several spans were moved together, the track rails on the bridge not being disconnected at all at the junction of the separate spans.

The old bridge was moved down-stream a total distance of about 25 ft., leaving the old piers (which are seen by the photograph to be in excellent condition) clear for the erection upon them of a new structure of modern design. This bridge is to have two decks, but we were in error last week in stating that one deck was to accommodate an electric railway. Instead, both decks are for the use of the railway company solely.

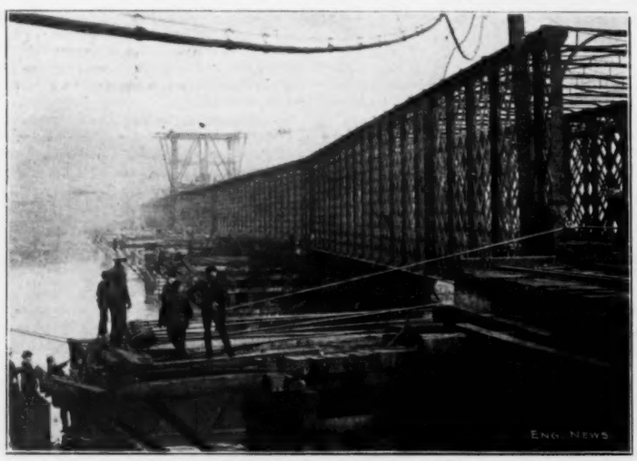


Fig. 1. View of Lower Side of Bridge.

Fig. 2. View of Upper Side of Bridge.

MOVING THE ALLEGHENY RIVER BRIDGE OF THE PITTSBURG, FORT WAYNE & CHICAGO RY.

The tracks on the through level are to be used for the local switching traffic connecting different freight houses, and also for trains over the Allegheny Valley Division. The tracks on the upper level are to be used by the through passenger and freight trains of the Pennsylvania Company's Northwest system.

The work of moving the bridge was done in about seven hours by the American Bridge Co. and the engineering force of the Pittsburg, Fort Wayne & Chicago Ry.

MAXIMUM TRAINS: THEIR RELATION TO TRACK, MOTIVE POWER AND TRAFFIC.*

By E. E. R. Tratman.†

Considerable attention has been given by the railway clubs to the treatment of the above question from the transportation point of view, showing the advantages of maximum loading. But it has been claimed that there is another side to the question, and that what seems to be gained in the transportation department may be more than offset by the repairs and renewals necessitated in other directions as the maintenance of way, of rolling stock and even of motive power equipment.

In certain cases, no doubt, the maximum loading has been carried to an extreme. But whatever may be the results in individual cases, there can, I think, be no doubt that the heavy engine, heavy car load and heavy train load have been proved satisfactory and have come to stay. It is futile for the equipment man to complain that the cars are being damaged by the new conditions, or for the maintenance-of-way man to complain about the effects upon the track, with any idea that the conditions will be modified to suit the cars or track. On the contrary, the cars and tracks must be made to fit the traffic conditions, and rightly so, since it is the traffic which makes the business and earns the revenue. There is not the slightest prospect of any backward step in the present tendency to consolidate freight traffic into heavy trains hauled by heavy engines, and it is the proper duty and work of the various departments of the service to facilitate operation of traffic under these conditions to the best of their ability.

On existing roads circumstances will decide whether it will be more economical to reduce the grades on any division or to use pusher engines to help the maximum trains over the heavy grades. Where heavy engines are introduced, bridges and other structures will very frequently have to be strengthened at considerable expense; when the trains are greatly increased in length, it may be necessary to lengthen sidings or double track and to put in additional sidings or passing tracks. The use of lap sidings with switches operated from a tower will greatly facilitate the movements of long, heavy trains, as the starting and stopping of such trains is troublesome and costly.

As an example of some of the expenses incidental to heavy engine and cars, it may be noted that in order to introduce this system of handling traffic on the Delaware, Lackawanna & Western R. R., the bridges have practically all had to be rebuilt, at a cost of some $4,000,000 (including the work yet to be done, which will extend over the next few years). As a result of the adoption of the heavy engines, it has been found necessary to provide stronger turntables wherever these engines are handled and also to enlarge roundhouses, coal chutes and other facilities. With the larger trains handled came the necessity for increased length of passing tracks and a third main track on heavy grades has become necessary on sections of the road where the heavy slow freight trains have been unduly delayed while waiting for superior trains to pass.

The following is an extract from the report of the Northern Pacific Ry. Co. for the year ending June 30, 1901:

> The increase of net income to the extent of 103.89% in the past four years, while largely due to the improvement in general business, could not have been attained in the face of voluntary reductions in freight and passenger rates but for the decrease of expenses of transportation through the intelligent application of the best methods known in the science of railroad operation and engineering. The results of such methods are shown in the following comparative statistics for that period, by which it will be seen that invested capital, labor and fuel have been utilized with an economy and profit seldom before shown in the solution of railroad problems of this country.
>
> Although there has been in this period of four years an increase of 67.46% in tons of revenue freight carried one mile, yet by increasing the tonnage loaded in each car 25.66%, and the number of loaded cars in each train 34.93%, the number of revenue tons in each train has been increased 69.57%, and the increase of 888,358,921 tons one mile has been transported in 1900 in trains that ran 85,181 miles less than was required for that much less tonnage under the methods and facilities of 1896.
>
> Although the mileage of loaded freight cars increased

*Abstract of a paper read before the New York Railroad Club, April 17, 1902.

†Associate Editor of Engineering News.

33.22%, and the average receipts per ton per mile decreased 12.65%, yet the total freight earnings per train mile increased 48.29%.

During the year 1900-1901 the number of road locomotives was increased 19.5%, but this represented an increase of 27.4% in horse-power capacity, this capacity being that which the engines are capable of developing continuously under speeds which are applicable to the service to which they are assigned. The number of freight cars was increased 24.7%, representing an increase of 31.8% in capacity.

TRACK IN RELATION TO MAXIMUM TRAINS.

It has been claimed that while the modern exceptionally ponderous and powerful engines with their heavy trains may be advantageous from an operating point of view, they are very severe upon the track and structures, and involve greatly increased maintenance work and expense. To arrive at some actual facts on these points, the writer made extensive inquiries relative to the wear and general injury or disturbance to track on divisions where the heaviest engines are employed, as compared with similar effects on the same or other divisions where engines and trains of more moderate weight are in service. These inquiries referred not only to the actual wear of rails (at joints and in the body, on curves and tangents), but also to the general injury, including wear of ties, breakage of frogs and switches, damage of bridge structures, and the general displacement and disturbance to track, which increases the work of the maintenance-of-way forces for keeping the track in proper line, surface and general condition. In the first place, then, let us see what actual definite information has resulted from these inquiries, the replies to which, from a number of railways, are given herewith.

1. As to the relation of heavy rolling stock to track maintenance, we now have in service upwards of 150 locomotives weighing between 180,000 and 200,000 lbs. These have been purchased within the past two years, too recently to admit of our having comparative maintenance figures of value. Of course large locomotives mean large outlays of money for rail and bridge renewals. These we are making. There is also additional expense for tie-plates and rail fastenings. The driving axle loads of these locomotives vary from 39,800 to 46,300 lbs. Rails and splice-bars are beginning to show evidence of weakness after subjecting them to such large stresses for several months. The large locomotive in service on a low-grade division is more damaging to track than on a division with heavy grades and of similar curvature. The increase in the deterioration of track on the low-grade division can be attributed in part to greater speed, but it does seem to be more the result of longer trains. A given number of cars handled in long trains will destroy track more quickly than the same number handled in trains of fewer cars, in shorter trains. This is due to a change in the condition of the ballast, which is softened (churned) by the passage of the wheels over the joints. With long trains the churning process is continued for a longer interval at any one time, resulting in the softening of the ballast and the sluking of the ties, with attendant low joints, damaged splice-bars and rails. With short trains the churning does not reach so advanced a stage."

2. We have experienced exceptional trouble with the heavy engines as compared with the lighter engines in service; this is noticeable in the wear of rails on curves, joints worn on the ties and damage to frogs and switches, especially in yards where our track is not as heavy as on the main line; the heavy engines cause a general disturbance of line and surface. As to their action on bridges we have no complaint other than that referring to the floors as we have very generally rebuilt and strengthened to accommodate these engines.

3. The Bessemer & Lake Erie R. R. uses consolidation engines of 250,000 lbs., with 225,000 lbs. on a driving wheelbase of 15 ft. 7 ins. These engines are operated over 100-lb. rails on the main line and over 85-lb. rails on the passing sidings. In our yards they are operated over 85-lb. and 60-lb. rails. We have not had any particular trouble on account of the rails breaking, but in our yards we have found it necessary in tracks that are used a great deal by these engines to replace the 60-lb. rails and switches with 85-lb. rails and switches. We found that by putting in extra ties we did not make the 60-lb. rail satisfactory for continuous use for these engines, as they bent the 60-lb. rails sideways, producing a wormy track which we could not straighten. We also had to replace the 60-lb. switches and frogs with 85-lb. switches and frogs on account of not being able to keep our switch points straight so they would close.

We find that the wear of rails on curves is more rapid. We also find on our lighter curves where we have not yet put in tie-plates that it takes more labor to keep the track to gage. Our bridges on the district where these engines are run are all built for these heavy engines, and so far we have not had any trouble here. These engines are run at a slow speed, so that I cannot say that we have had any extra trouble on account of any general disturbance of the line and surface.

4. Mr. George W. Kittredge, Chief Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Ry., states as follows on this subject:

We have experienced more or less breakage of frogs and switches and a greater or less increase in track work and expense of general maintenance since we have put our heavier engines and train loads into use, but I am not prepared to say this is due wholly to their increased weight. Our business has been such during the past year that we have run our engines for a considerable length of time after they properly should have been sent to the shop. In general our experience with the heavier engines is that so long as track is kept good they do not affect it seriously, but that if it becomes rough or out of adjustment from any cause, such as freezing or thawing, they very soon render it "bad track" if not immediately adjusted. So far as our structures are concerned we have had to renew many light bridges on account of their inability to carry heavy loads.

It is a difficult matter to formulate accurately in figures just what the results are to maintenance of way on account of the greatly increased weights of engine equipment.

A. There is undoubtedly an increased wear and tear on track. The heavy loads make necessary the replacement of light rails, not so much on account of the wear, which is proportionate to the tonnage, as on account of the bending and distortion; they make necessary earlier renewals of ties because the heavier weights break ties which would carry lighter weights.

B. In regard to switches and frogs, the wear and tear on these is increased rapidly on account of the hammering.

C. In regard to wear on bridges, the heavier loads have made necessary the replacement of numerous bridges which were designed for lighter loads. With the newly designed and newly erected bridges I do not expect there is any more wear and tear proportionately than there was in the old.

D. In regard to general disturbance to line and surface, this disturbance is effected not only by the heavy loads, but also by the amount and condition of ballast and ties. Mud-ballast track might carry light engines and cars, but would not answer at all under heavy ones.

Any improvement to give an economical track for heavy service must, as a rule, include the entire track. Heavy rails on old or widely spread ties and deficient ballast will not give the results which the expenditure for the rails properly calls for. Nor is it sufficient to renew ballast under light rails or widely spaced ties, for the heavy loads will bend the rails, causing a pumping and churning motion of the ties which churns and grinds the ballast, causing its gradual disintegration. In view of the economical results that have been attained by large expenditures for reducing grades and curves, it will in general be economical to provide for an ample supply of good ballast and ties, with heavy rails and stiff joints, on divisions where very heavy engines and trains are to be operated. No reference will be made here to new types of track construction, with concrete foundation, steel or concrete ties, etc. Such changes may come, but they will be slow and gradual, and what we have now to deal with is the improvement and strengthening of our present type of track.

The use of ties of steel, concrete, or other substitutes for wood has made but little progress and even the use of treated ties has made slight progress in view of their undoubted advantages and economies to be derived from their use. Ties of very inferior wood, properly treated, may cost less and last longer than untreated ties of better wood. Then, too, some railways which do use treated ties lose a part of their value by treating them while still wet and sending them out on the track as soon as they come from the treating plant, although their life would be materially increased if they were allowed to season for a time before treatment and then allowed time to dry out after treatment. At this time, however, there seems but little chance of an improvement in our happy-go-lucky methods of using ties and wasting timber. The number of ties used and the cost of renewals show little signs of diminishing and there is no reason to expect it under present relations of track to traffic.

The advantages of heavy, well-made rails are not only in the greater life and the better condition of track, but also in reducing the slipping of engine wheels and increasing the hauling capacity of the engines. In rail joints the tendency is decidedly towards some kind of bridge or base support to hold up the rail ends and make the joint as stiff as (but no stiffer than) the rail. This has to some extent reduced the trouble from bending of the splice bars, due to the use of steel of too soft a quality, but no radical improvement has been made in the shape or quality of the bars.

In frogs and switches, as might be expected, considerable trouble is experienced with heavy loads. Both rigid and spring frogs show the results of the severe service, especially if made of comparatively light rails, and as for switches, especially those with short switch rails for sharp turnouts, it is almost impossible to reinforce the thin end of the switch rail sufficiently to prevent its being cut and bent by the heavily loaded wheels which it has to guide by the flanges. Some improvement has been obtained by the more general use of some of the improved switches and "frogless" frogs which are now being introduced to some extent. In some of these switches and frogs an unbroken main line rail is given and as the frog device is only used by trains taking the turnout it is not subjected to any strain or wear by main line trains, as is the case with ordinary spring or rigid frogs.

In very many cases the side track capacity must be increased and it may be economy even to extend double track or build lap sidings (with switches operated from the towers) so as to facilitate the movements of long, heavy and slow trains. It may also be found necessary to materially strengthen the track construction in yards.

There seems to be no doubt that the work and expense of track maintenance have increased with the use of heavy engines and trains. Apart from an increase in renewals there is the general extra work of tamping ties, raising joints and lining, surfacing and gaging track due to the disturbance and dislocation caused by the heavier conditions of traffic.

MOTIVE POWER AND EQUIPMENT IN RELATION TO MAXIMUM TRAINS.

In the table of heavy engines which is now presented, the heaviest are road engines; decapods of 129½ tons and consolidations of 125 tons. Of the engines on the list nearly all represent large numbers of each type on the various roads. The two Illinois Central R. R. engines, however, are single examples only, built partly for experimental work and never duplicated. The wheel loads are averages, but actual loads on the main drivers are somewhat heavier. Thus the mogul freight engines of the New York Central R. R., with an average of 24,550 lbs. per wheel, have 27,600 lbs. on each main driver. The Erie R. R. engines have driving wheel loads of 19,900 to 23,150 lbs., and the ten-wheel passenger engines of the Union Pacific Ry. have loads of 23,000, 25,500 and 23,500 lbs. on the leading, main and trailing drivers. In tenders, we run as high as 134,000 lbs. on the Atchison, Topeka & Santa Fe Ry., 126,400 lbs. on the Erie Ry. and 120,000 lbs. on the Chicago, Milwaukee & St. Paul Ry., giving average loads of 16,750, 15,000 and 15,800 lbs. per wheel.

Freight cars have increased to 80,000, 90,000, 100,000 and even 110,000 lbs. capacity and as these cars are mainly used for bulk freight (coal, ore and ballast) they are on many roads systematically loaded above their rating. We have 90,000-lb. gondolas weighing 39,000 lbs., 100,000-lb. gondolas weighing 35,000 lbs., and 100,000-lb. box cars weighing 43,000 lbs.; these give (at full loading) wheel loads of say 16,200, 16,875 and 18,000 lbs. Steel ballast cars on the Union Pacific Ry. are loaded with 60 tons of gravel and give a wheel load of about 20,000 lbs. per wheel. Consider a hundred wheel loads of this sort in one train going over the track and converted into hammer blows at low joints or soft spots in the ballast and you will have some idea of what the engineer and the maintenance department have to contend with in keeping the track in proper condition.

Table of Weights of Locomotives.

Railway.	Type.	Weight. Total, lbs.	Weight. On drivers, lbs.	Per driving wheel, lbs.	Driving wheel base, ft. ins.
A., T. & S. F.	Decapod.	259,000	232,000	23,200	20 0
B. & L. E.	Cons'dation.	250,000	225,000	28,125	15 7
Ill. Cent.	12-wheel	232,200	193,200	24,150	15 9
Union	Cons'dation.	230,000	208,000	26,000	15 7
Leh. Vall.	"	228,000	205,000	25,625	15 0
Ill. Cent.	"	218,000	198,000	24,750	16 3
A., T. & S. F.	"	214,670	191,370	23,920	15 4
"	Prairie.	210,800	147,500	24,583	13 8
M., St. P. & S. S. M.	Decapod.	207,210	184,300	18,430	19 4
So. Pac.	Cons'dation.	204,800	181,200	22,650	15 8
Leh. Vall.	"	202,200	177,500	22,187	16 3
Cen. N. J.	12-wheel.	202,000	160,000	20,000	15 0
Leh. Val.	10-wheel.	191,758	138,348	23,058	13 0
Cen. N. J.	Atlantic.	190,600	99,400	24,850	7 8
Chi. T. T.	Cons'dation.	190,280	169,140	21,142	14 8
N. Y. Cen.	"	190,000	164,000	20,500	17 0
Erie	"	189,400	165,900	20,737	17 0
Union Pacific.	"	188,585	162,750	20,344	15 3
"	10-wheel.	182,940	141,320	23,553	14 6
Plant	"	176,500	127,000	21,166	14 1
M., St. P. & S. S. M.	Cons'dation.	176,100	154,500	19,312	16 6
N. Y. Cen.	Atlantic.	176,000	95,000	23,750	7 0
L. S. & M. S.	Prairie.	174,500	130,000	21,666	14 0
C., R. I. & P.	Atlantic.	167,500	93,500	23,375	7 0
Chic. & N. W.	"	160,000	90,000	22,500	7 0

The following are some comments from individual railways as to the relations of maximum trains to equipment:

(1) From Mr. W. H. Marshall, Gen. Supt. of the Lake Shore & Michigan Southern Dy., I have the following statement:

"We do have more wear and tear and damage to cars, break-in-twos of trains, etc., by using a larger locomotive, but I do not think this will continue, for the time will come when the weak cars will be entirely removed from the service. We are extending our policy of introducing heavy engines, and while we are not increasing the size over what we have considered our standard for the last year, we are buying more of them. I do not think that the tendency towards increase in engine weights and train loads has reached its limit."

(2) With our large engines of 176,000 lbs. to 185,000 lbs. we have not noticed that there has been any more damage to cars than formerly, nor have we noticed an increase in the number of break-in-twos, but it is natural that this would occur. In connection with the use of the big engines we are cutting out dips and reducing grades, thus eliminating points at which break-in-twos naturally occur. We think the general cost of handling the traffic has been reduced, train expenses have been reduced, engine repairs have increased and the fuel consumption per ton hauled has certainly decreased. We feel that we have about reached the limit in our large engines, and that it will be a long time before they are again increased. The tendency towards the increase of train loads has, in my opinion, about ended. There is a limit where the slow speed of a heavy train makes it more expensive than the greater speed of a lighter train, and this point has about been reached with our big engines.

One considerable trouble which has been encountered in large, heavy trains is in failures of the draft rigging, both in tension and in compression; these occur both on the road and in yard service. It has been contended by some car department officers that the cars are handled with undue severity in switching, and they should not be subjected to such severe treatment or the draft rigging expected to withstand it. It is doubtful, however, if the cars are, as a rule, handled with any less care than formerly, but with 80,000-lb. and 100,000-lb. cars switched at the same speed as 60,000-lb. cars the former will deliver much more severe blows to the cars against which they are switched. The use of the heavy cars will continue to increase, and the only proper course is to build them so that all parts will stand the strains to which they are subjected in regular service. It may be noted in this connection that while the weight and capacity of cars have increased, the draft rigging and attachments in very many cases are practically the same as in the lighter cars. This, of course, is likely to be a serious cause of trouble for which the heavy car policy is not to be blamed.

Another question which has been brought up is that of the car wheels. Can cast-iron chilled wheels be made which will safely and economically stand the service under

100,000-lb. cars? A number of the officers of leading railways believe that such wheels can be made. It is only reasonable to expect that increased care and increased weight may be necessary, with consequently increased cost; the increase in cost, however, will be small as compared with the alternative of adopting steel-tired wheels for freight service. In view of these facts, the railways should by no means quibble over an increase in the cost of chilled cast-iron wheels for the large-capacity cars. It was pointed out in a discussion on "Revenue Train Loads" at a meeting of this club in May, 1901, that larger wheels should be used with the larger axles for heavy cars—say 36 and 38-in. wheels.

In the safe and efficient handling of long trains of these heavy cars an important feature is the provision of ample braking capacity. The brake equipment must also be kept in good condition, although tests of heavy trains on mountain grades have shown that this is not universally done. In view of the fact that the cars are often run nearly or quite empty, it is very difficult to regulate the braking power. This trouble is specially severe on lines with long and steep grades. In a paper recently presented before the Pacific Coast Railway Club, Mr. H. H. Forney, General Air Brake Inspector of the Southern Pacific Ry., remarked that he had had occasion to take a train of 28 cars down the Tehachapi incline and attempted to handle the train with one engine. He had 105 lbs. of air on starting, but it was necessary to call for hand brakes before the train had gone a mile from the top of the grade; in spite of the combined efforts of the air and hand brakes the train ran half a mile through the Mojave yard before stopping. He did not regard adjustable brake rigging with approval, but thought the remedy would be in applying to these cars a foundation rigging strong enough to withstand twice the present strain and then equip the car with two brake cylinders of the present size, connecting to the same system of levers—this equipment to be so arranged that when the car is empty one cylinder will be in use and the car will brake at 75% of its light weight; when loaded both cylinders will be "cut in," which will raise the braking percentage to 150% of light weight, or about 35% of total load. With such an arrangement the desired result could be obtained by the use of standard apparatus, the liability of slid-flat wheels would not be as great as at present and the requirement would be simply the "cutting in" or "cutting out" of one brake cylinder.

This plan, however, would be very costly, and has the greater objection of requiring every car to be cut in or cut out according to its loading. It seems almost certain that this would lead to considerable trouble and probably to accidents. Retarding force applied unequally throughout a long and heavy train is one cause of trains parting. To ensure as nearly as practicable a uniform retardation of all cars in the train there must be, first, quick application throughout the train, second, uniform pressure in brake cylinders, third, uniform pressure on brake-shoes, and fourth, uniform coefficient of friction of the brake-shoes on the wheels.

CONCLUSIONS.

From the facts and figures which have been presented and discussed in this paper certain conclusions may be drawn, and are stated briefly below:

1. The heavy engines, cars and trains for freight service have come to stay, for the reason that the "maximum train" method of handling the traffic has shown an ultimate economy in spite of the large sums expended in improving the road and the rolling equipment.

2. There is undoubtedly an increased wear of the track and cost of maintenance of way due to the heavy equipment and trains and it would be wise economy in very many cases to make liberal expenditures in materially increasing the strength of the track. The engineer has been able to show conclusively the ultimate economy to be obtained by large expenditures in general improvements and it is now time for the engineer of maintenance of way to show a similar economy to be obtained by expenditures upon the track itself. If he fails to impress the management with a realization of these economies, the only thing to be done is to make the best of what he has for there is no chance of driving away the heavy engines, cutting down the car loads, or reducing the train loads to conform to the economical capacity of the existing track. Besides the track proper, improvements in passing tracks, double tracking, yard and terminal facilities, etc., offer further opportunities for effecting economy in operation.

3. While the present large engines and cars are generally satisfactory, many improvements remain to be made, especially in reducing the dead weight and strengthening the weak parts which develop under the severe conditions of service. Improvements in draft rigging, in brake equipment and in the proper maintenance of coupler and brake equipment are specially to be noted. It seems unlikely that the capacity of cars will be increased. Such a step is neither necessary nor desirable, for, with the exception of certain class of freight (and these often hauled in one direction only), the large cars are very frequently run with loads far beneath their capacity.

4. It would seem that we have about reached the limit of economical weight of the locomotives. Actual weights may still be exceeded in certain cases, but engines of 90 to 125 tons may fairly be considered to represent the limit in mere power and weight. The future progress will be rather in increasing the number of such engines, in improving their construction to obtain further economy in service and in improving the methods designed to work them to their full capacity.

5. The tonnage rating system for making up trains has by no means reached its full development, either in the facility of its application under varying conditions or in securing the desired end of uniformly giving the engines a full load. In fact, much greater development may be expected in these directions than in the direction of building heavier locomotives.

6. Improvements are much needed in the work of getting the traffic over the road with as little delay as possible. These may be effected partly by increased track and terminal facilities, additional tracks, modern water and coal stations, the block system, etc., but more especially by greater promptness in handling cars and trains at division and terminal points. Closely related to this matter are the problems of restricting the use of cars for storage and the improper use of foreign cars. An auxiliary fast service of smaller and lighter cars for the economical and prompt handling of small shipments in local freight traffic may come at some future time as an offset to the comparatively slow and enormously heavy trains of large-capacity cars.

And finally the writer would repeat that railways are not operated with a view to the economical service of their various departments. On the contrary, the departments must be run with a view to the economy and efficiency of the operation of the railway of which they form a part.

DISCUSSION.—Mr. P. H. Dudley contributed a written discussion, and referred to his own labors in the line of producing better track. He was the first to work for stiffer rails, a movement that soon grew to be universal, until we now have the deep 90 and 100-lb. rail on all our main lines. The matter of rails is of particular importance when considering maximum trains, in view of results of experiments made with his latest form of track-testing apparatus, which enables him also to find the stresses in the rail set up by a load moving over it. He found that the comparative effect of two engines on the roadbed is the same as if their weights were considered distributed over the length of their wheelbase; the effect on the rail, however, depends on the wheel loads directly. This draws attention to an important need of modern times in the matter of rails—a rail of better composition, or higher resisting qualities—and the speaker stated that his efforts in this direction had met with some success.

Mr. Geo. L. Fowler said that some roads actually find it cheaper to run light trains, due largely to the character of their traffic. Again, in reference to the great amount of grade reduction and other line-improvement work now being done to accommodate heavy traffic, he knew of one road that found it cheaper to use pusher engines than to pay the interest on the cost of grade reduction.

The speaker then alluded to the breakage of cast-iron car wheels under modern heavy loading. Some roads had found the wheels to stand up perfectly under 80,000-lb. cars, but with 100,000-lb. cars the breakages became a serious matter. Other roads again used cast-iron wheels under 50-ton cars satisfactorily. The speaker raised the question of whether the cast-iron wheel had not reached its limit with the 100,000-lb. car.

Mr. J. N. Barr, Mechanical Superintendent, Erie Ry., brought up a matter that had not yet been mentioned: the maintenance of motive power under heavy service. He instanced the matter of packings under 200-lb. steam pressure, boiler maintenance with heavy and high-pressure service, handling of compound engines, etc. A better grade of maintenance work is needed for this, he said; the rank and file of the men who handle these things are not educated up to the point of properly caring for them.

Mr. Geo. W. West, Supt. of Motive Power, N. Y., O. & W. Ry., spoke of the overloading of engines, particularly in switching and yard work, as being responsible for much of the damage to those parts of the track. Engines are taxed to a point where they slip their drivers at crossings, frogs, switches, etc., thus concentrating the wear at these points. He summarized one of the answers reported in the paper as being a fair conclusion: modern heavy track under heavy traffic stands up just about the same as the lighter track under the lighter traffic. Mr. West also referred to the relation of terminal accommodations to traffic. He feared that most of the gain from concentrating traffic in long, heavily-loaded trains might be lost in the extra delay and expense in terminal work.

Prof. H. W. Hibbard stated that he saw much promise in the four-cylinder balanced compound locomotive; with its great power and perfect balance of rotating and reciprocating parts he thought it would be a great factor in the future development of heavy and fast traffic.

Mr. H. G. Prout, editor of the "Railroad Gazette," thought that from the experience gained up to the present with heavy traffic no close conclusions could be drawn; matters are still in a state of movement, of which the end is not yet in sight. Enlarging on a suggestion contained in the paper, he thought that freight traffic might differentiate; in addition to the regular heavy bulk-freight traffic a light freight business might develop and reach considerable importance. On the other hand, it is possible that the rapidly developing electric railway systems may take care of some or all of this lighter freight work at least for short distance shipments.

THE NEW SEWAGE DISPOSAL WORKS AT PITTSFIELD, MASS.

The city of Pittsfield, Mass., will soon complete a sewage disposal plant to take the place of its temporary outlets into the Housatonic River. The plant includes a receiving reservoir of about 1,500,000 gallons capacity, a 4,800,000 gallon electric power pumping plant, a force main over two miles long, and an intermittent filtration area of nearly 25 acres. Provision has been made for increasing the capacity of the pumping station, and the city owns sufficient land to double its present filtration area. One of the noteworthy features of the design is the provision of a reservoir of such capacity that the pumping station and filter beds may be operated within the eight-hour day for municipal employees which is in force in Pittsfield.

The population of Pittsfield increased from 17,281 in 1890 to 21,766 in 1900. A public water supply was introduced in 1855 by a section of the old town which was virtually incorporated as a fire district. The fire district was abolished when, in 1891, the town become a city. In 1890 the town secured legislative authority to construct a comprehensive sewerage system, and in 1901 plans therefor were approved by the State Board of Health. The approval permitted the discharge of crude sewage into the Housatonic River until June 1, 1900, after which it was understood that the sewage would be treated by intermittent filtration. An extension of time was subsequently granted. Sanitary sewers were put in use in or about 1893, and extensions have been made year by year since that time until on Dec. 31, 1901, there were 29.89 miles of separate sanitary sewers. On the same date there were 2.57 miles of combined sanitary and storm sewers, and 5.5 miles of saparate storm sewers. It is quite likely that the combined sewers were the first ones built, but the date of their construction is not at

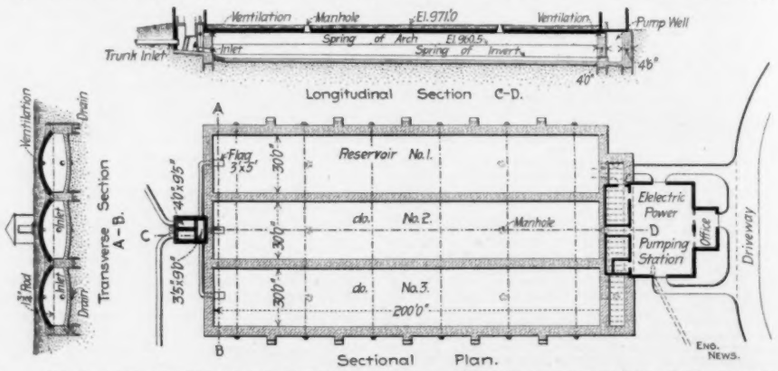
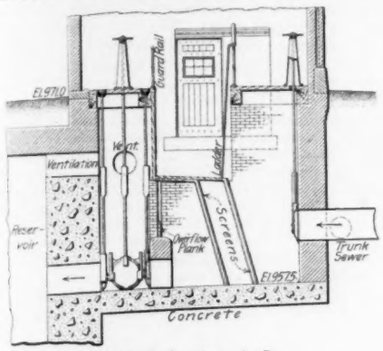


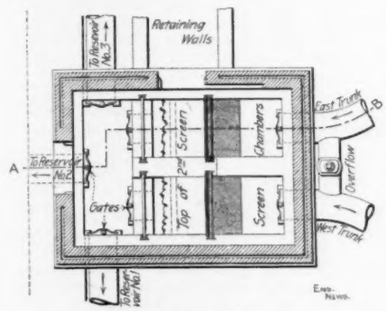
FIG. 1. PLAN AND SECTIONS OF SCREEN HOUSE, RECEIVING RESERVOIR AND PUMPING STATION, PITTSFELD SEWAGE DISPOSAL WORKS.

J. J. Van Valkenburgh, Consulting Engineer; Arthur A. Fobes, Engineer Board Public Works.

hand. By way of comparison it may be stated that the city has 64.48 miles of water mains, as compared with the 32.46 miles of sewers which receive household wastes. Gagings of sewage flow made in 1900 and earlier indicated that the sewage disposal works should have a daily capacity of 2,000,000 gallons. The disposal works have been built under the direction of the Board of Public Works of Pittsfield, of which Mr. Jas.



Vertical Section A-B.



Sectional Plan.

Fig. 2. Plan and Section of Sewage Screen House.

L. Bacon is chairman. The board engaged Mr J. J. Van Valkenburgh, of South Framingham, Mass., as consulting engineer, and the works were designed and their construction supervised by him. All surveys were made and data for plans supplied by Mr. Arthur A. Fobes, Engineer of the Board of Public Works, and his assistants. Mr. Fobes has also been in general charge of construction, with Mr. James C. Harding, Assistant Engineer, in direct charge. The following information regarding the disposal works has been abstracted from the annual report of the Board of Public Works for 1901. We are indebted to the board, and to Messrs. Van Valkenburgh and Fobes for the blue prints from which our illustrations were prepared.

The receiving reservoir and pumping station are located near the Housatonic River, at the temporary outlets of the two trunk sewers. A length of 225 ft. of 18 × 27-in brick sewer and 85 ft. of 24 × 36-in. brick sewer were built to connect the trunk sewers of the same size with the receiving reservoir.

Fig. 1 shows a plan of the reservoir, with the screen house at one end and the pump well and pumping station at the other end; also two sections through the reservoir. A larger plan of the screen house with a corresponding longitudinal section, is shown by Fig. 2. As is best shown by Fig. 1, the screen house is divided into two screen chambers and one gate chamber. The details of the screens and of the 24-in. sluice gates are shown in Fig. 3. The latter gates control 24-in. inlet pipes to the reservoir.

The reservoir is in three compartments, each 30 × 200 ft., and has a capacity of about 1,500,000 gallons. The pump well is 8 ft. wide and 85 ft. long. The sides and invert bottom of the reservoir are of concrete, 1½ ft thick along the center line and 2 ft. thick at the side walls. The bottoms have a longitudinal slope of 6 ins. per foot towards the pump well. The reservoir is covered with arches of a single span of 30 ft., a radius of 22 ft., a rise of 6 ft. and a thickness of 2 ft. Above the crown of the arches there is 2½ ft. of earth filling. The pump well is covered with brick arches resting on 8-in. I-beams spaced about 3 ft. apart.

Some of the details of constructions are described by Mr. Van Valkenburgh in the annual report already mentioned as follows:

> Since the reservoirs are located within 250 ft. of the river and the intermediate ground is of a gravelly nature and full of water, a line of 4-in. spruce, tongued and grooved sheet piling was first driven on the side lines of all proposed walls, and to a depth of 3 ft. below bottom of foundations. The material between the lines was then excavated to a depth that would allow a 6-in. drain pipe embedded in gravel being laid below the foundations of the walls.
>
> The walls were then built solid between the lines of piling up to the springs of the inverts and the inside of line of piling cut about 2 ft. lower at the spring of the bottom line of the inverts.
>
> Carpenters then erected strong forms on the inside line of the concrete walls to be built, and the latter were carried up to their proper elevations. The material was then excavated from between the walls thus built, the 8-in. drain laid, and the inverts formed.
>
> The wisdom of this method of construction is evidenced by the fact that the contractor has experienced scarcely any trouble in securing good foundations. Occasionally, however, a pump would stop and then the water would immediately rise and cause work in the trenches to be suspended for the time being. But in no case was anything encountered which necessitated the foundations to be carried to a greater depth or changed in any respect from that indicated on the plans.

The work described involved some 4,100 cu. yds. of 1:2:5 concrete. Atlas Portland cement was used. Most of the gravel was from the reservoir excavation and the balance came from near by. The bulk of the concrete was prepared in a steam concrete mixer.

The screen house and reservoir are ventilated through the chimney of the pump house, both by natural draft and by means of an electric fan.

The pump and screen house are of brick, faced with repressed brick and trimmed with rock-faced Monson granite. The main building is 36 × 51 ft., besides which there is one addition 12 × 36 ft. and another 13 × 47 ft. The floor is composed of brick arches, resting on 8-in. I-beams, placed about 3 ft., c. to c., and with the space above the arches filled to a level with concrete and finished with 2 ins. of granolithic material. The station is to be heated by hot water and provided with modern plumbing conveniences.

A single pump, capable of delivering 2,000,000 gallons in ten hours through about 11,500 ft. of 24-in cast-iron force main, with a combined suction lift and head of 39.5 ft., and a friction head in the force main of 12.7 ft., has been provided. It is a horizontal, triplex pump, driven by a direct-connected synchronous motor.

The actual length of the force main is 11,476 ft. It is of light weight pipe, averaging about 175 lbs. per ft. The four summits on the pipe line are provided with air valves.

The filtration area borders the Housatonic River, a little over two miles below the reservoir and pumping station. At this point the city owns 90 acres of land, of which Mr. Van Valkenburgh originally laid out about 48.5 acres, including embankments, in 57 possible beds. It has since been found that the soil at the site of one of the beds is too poor to warrant its use. Thus far, 27 beds have been prepared, requiring a total area of 24.78 acres, and leaving some 22 acres available for filtration after deducting the space occupied by embankments.

The beds are divided by embankments 4 ft. wide on top, and are composed of loam taken from the site of the beds. Vitrified distribution pipes are laid in the embankments and have diameters of from 20 to 8 ins., according to the area served.

Manholes are placed at intervals of about 100 ft. in the east and west carrier lines. These are provided with spear gates (Fig. 3), so the sewage may be turned on the adjacent beds at either the north or the south sides through 8-in. outlet pipes, discharging on an area 5 × 5 ft., paved with stones 15 ins. deep, set with their tops 2 ins. above the level of the beds. At a distance of 22 ins. from the mouth of the outlet pipe a single paving stone 13 ins. wide and 3 ins. thick projects 1¾ ins. above the others to break the force of the sewage and spread it in every direction The beds have been graded to a level surface, but for winter use Mr. Van Valkenburgh recommends that they be furrowed deeply to facilitate the distribution of sewage beneath the snow.

The underdrainage system is composed of a line of 6 to 12-in. pipes laid in an easterly and westerly direction through each of the five rows of beds, and of 3-in. branches, spaced about 35 ft. apart, including, but of course avoiding, the space occupied by embankments. The drains are laid about 4 ft. below the surface, at a grade of 6 ins. to 100 ft. Bell and spigot vitrified pipe was used for the drains. The joints were left open, and were covered with 4 ins. of coarse screened gravel and 2 ins. of fine gravel. The main underdrains discharge into ditches leading to the Housatonic River.

The contractors and contract prices, so far as given in the report, were as follows: Connections with outlet sewers, screen house foundations, reservoir and pump well, Troy Public Works Co., Utica, N. Y., $51,340. Screen house superstructure and pump house, J. J. Prindiville, South Framingham, Mass., $9,548. Power pump and electric motor, Stillwell-Bierce & Smith-Vaile Co., Dayton, O., $9,419. Cast-iron pipe for force main, Chas. Millar & Son, Utica, N. Y., (about) $25,000.* Special bridges for force main, Collins & Norton, $980. Filtration area, with distribution and underdrainage systems complete, Newell & Snowling, Southbridge, Mass., $18,573.† These items make a total of $114,860. The force main was laid by the city and the cost of the work is not given. All cast-iron valves were made by the Coffin Valve Co., of Neponset, Mass. The 90 acres of land at the filtration area, together with a right of way for a

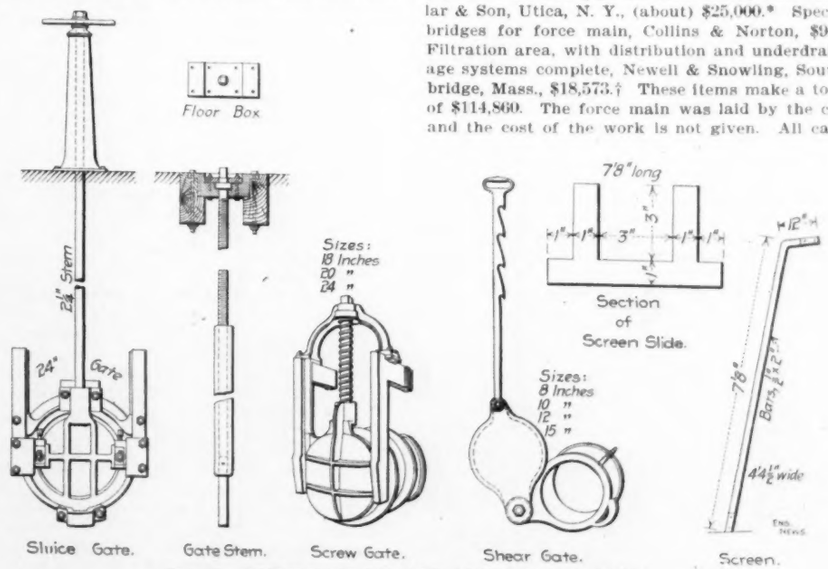


FIG. 3. DETAILS OF SEWAGE SCREENS AND GATES.

*Reported at 11,476 ft., averaging about 175 lbs. per ft., at $26.70 per long ton f. o. b. cars in Pittsfield.

†The bids were based on 65,000 cu. yds. earth excavation (which proved to be much too low an estimate); 100 cu. yds. rubble concrete; 63 manholes; 138.8 to 24-in. gates; 27,764 ft. 3 to 12-in. underdrain; and 7,460 ft. of 8 to 24-in. distribution pipe.

part of the force main, cost $13,240. About $800 additional will be paid for the right to lay the force main through other private property.

The electric motor was supplied by the Stanley Electric Co. of Pittsfield, under the pump contract. It is subject to a guarantee not to require more than 75.4 E. HP. per day of ten hours to pump 2,000,000 gallons of sewage, under a combined static head of 39.5 ft. and a frictional head estimated at 12.7 ft., making a total of 52.2 ft. The Pittsfield Electric Co. has agreed to furnish power at the pumping station for $40 per E. HP. per year.

SINKING A SHAFT BY THE FREEZING PROCESS AT RONNENBERG, GERMANY.

A shaft has recently been sunk by the freezing process, at an alkali works, at Ronnenberg, near Hanover, Germany. The work was done by the Societe Francaise d'Enterprises, and is described in "Le Genie Civil" for Feb. 1, 1902.

Soundings made by the Alkali Society of Ronnenberg showed that the bed of salts of potash lay at a depth of about 459 ft. To the depth of 407 ft. the ground was largely composed of gypsum, very much fissured and very irregular; but immediately overlying the salt formation was a 50-ft. stratum of hard and compact gypsum.

An attempt was first made to cut out the gypsum by a truss armed with cutting tools, and to lift out the water. The shaft was designed to have a clear diameter of 19.68 ft.; but for the first 46 ft. this diameter was enlarged to 26.56 ft., and it was lined with masonry 2.62 ft. thick. Inside the 21.32-ft. diameter thus left the cutting-truss was operated, and an annular cast-iron ring, 19.68 ft. diameter, was forced down by powerful hydraulic presses. The water met with, down to a depth of 23 ft., was lifted by eight pulsometer pumps having a total capacity of 1,553 cu. ft. per minute.

But during the sinking operation both the masonry and the iron lining began to move under the pressure of the very treacherous soil traversed; and in its total height the masonry showed a divergence of 3½ ins. from the vertical. All attempts to straighten the masonry failed; and at a depth of 105 ft. the divergence was about 4 ins. Finally, after using sheet-piling to reinforce the iron ring, the soil rushed into the shaft from the bottom and filled it to a height of over 26 ft. The water also began to increase in quantity until it amounted to 1,412 cu. ft. per minute, or almost the capacity of the pulsometers. Under these conditions it was impossible to continue with the method at first adopted, and the company determined to use the freezing process.

The two points to be decided were: Whether freezing would give good results in this fissured soil; and as the water at Ronnenberg was saline, with 3% salt at a depth of 105 ft., it was uncertain whether the freezing process would be successful under this condition. The first point was decided in the affirmative. And as to the second, experiments were made with different saline solutions of 4, 8, 10 and 12% of NaCl. These solutions were submitted for 24 hours to a temperature of — 12°C.; at the end of this time it was found that the 4% solution was almost solidly frozen; the others were less so; and the one of 12% was very little affected at the end of 48 hours. As a result, it was concluded that while the saline solution rendered the application of the freezing process longer in time, it was still practicable by increasing the number of freezing tubes, prolonging the time, and by using more powerful machinery.

The installation included 30 tubes sunk to a depth of 413 ft., on a circle 29.5 ft. in diameter. This work was commenced in July, 1899; and meanwhile freezing machines, of the Fixary system were installed, double in capacity those that would have been used for a non-saline soil. In sinking these tubes it was found that the soil penetrated was exceedingly irregular; it was unstratified and nodules of gypsum seemed to be embedded in masses of clay; this formation afforded little chance for water-bearing seams, and this danger was removed. The last tube was sunk on Dec. 10, 1900. On Dec. 5, a beginning was made in sinking the central tubes and in uniting the tubes by a series of circulating pipes.

The actual freezing operation was commenced on Jan. 19, 1901, and by March 27, the temperature at the bottom of the shaft was — 4° C. The actual sinking was commenced on April 18, using the two compressors; but after July 1, only one compressor was employed. To avoid disturbing the surrounding ground, all of the material near the walls of the shaft was removed by hand, explosives being used in the central core only. On July 15, the excavation had reached a depth of 226.3 ft. without any accident. It should have been said before that the outside diameter of the new shaft had been fixed at 26.5 ft., with a diameter of 18 ft. inside the masonry portion. When the cast-iron lining, sunk in the original attempt, was met with, it was removed entirely by thawing out about 3 or 4 ins. of the circumference by a current of warm air; a segment was then broken from the ring, and the rest was easily taken out; each ring taken out was replaced at once by a ring of the new shaft. The shaft was successfully completed some time in August, 1901.

NOTES FROM THE LAST REPORT OF THE STATE ENGINEER AND SURVEYOR OF NEW YORK.

The report just issued by State Engineer and Surveyor Edward A. Bond covers the fiscal year ending Sept. 30, 1901. Some of the special features of this report are here noted.

One of the important public works conducted by Mr. Bond—in co-operation with the U. S. Geological Survey—is the measurement of the volume of streams and the flow of water in the State. This work is done in accordance with an Act of Legislature of April 13, 1900, and the results of 1900 have been published and those of 1901 are given in this report. With the rapidly growing demand for water supply for the towns and cities of the State, and the desire to develop water powers throughout the State, the importance of this work cannot be overestimated.

The method of conducting these measurements is set forth in detail. When the work was commenced in April, 1900, gaging records were kept at 20 stations, most of these having been established in connection with the Upper Hudson Storage Survey of 1895-96, and by the U. S. Board of Engineers on Deep Waterways of 1897-99. These stations were all in connection with dams and mills. On dams the length and profile of the crest was determined at low water, and the volume of flow, corresponding to a series of observed depths on the crest, was computed by the weir formula, using the formulas of the U. S. Board of Engineers on Deep Waterways and that of John R. Freeman for the coefficient C, taking into account the modifications of discharge due to variations in the width of crest, slope and form of aprons, etc. Various methods of gaging were employed, as best adapted to conditions. At the newer stations a modified form of the Price meter—as adopted by the U. S. Geological Survey—was employed. This meter is usually submerged 0.6 of the depth of the stream at measured intervals across the channel, and the revolutions are recorded for a period of 100 seconds. In cases of doubt, surface and bottom velocities are taken, or the flow given is checked by the method of integration. The mean velocity in vertical planes is also measured from time to time to check the accuracy of the 0.6 method, and also to detect progressive changes due to sedimentation or scour. The report gives the formulas used in calculating the gaging records, and the tables of daily discharge are described. This portion of the report covers the record for each station separately and in detail, with the methods adopted at each station so described and illustrated as to enable the interested reader to clearly understand them and to judge of their probable accuracy for himself. These records cover, in tabular form, mean daily gage readings of elevation of water surface, the drainage area in each case, estimated pondage area, current meter discharge records, mean monthly run-off, mean daily flow, etc. Numerous half-tone illustrations show the characteristics of various streams, form of dams, etc.

The report on spirit-leveling on the line of the Barge Canal Survey of 1900 contains much valuable matter on this head. The instrument used was a Gurley Y-level, with a focal length of 16½ ins., clear objective aperture, 1¼ ins.; magnifying power, 35 diameters. The value of one division of the level-bubble was determined by the methods recommended by Prof. J. B. Johnson, and found to be 7.04 seconds, instead of 10 seconds, as given by the maker. The rods used were also accurately tested. The instructions issued for leveling are here quoted in full:

INSTRUCTIONS FOR LEVELING.

(1) All lines, both forward and backward, shall be run with two rodmen.

(2) Each rodman shall keep separate notes of rod readings on all turning points and bench marks he leads on and compute the elevations of the same when furnished with the height of instrument by the recorder. Each rodman, when he receives the signal "all right" from the instrument man, shall at once read the rod and record the reading in the book provided. The recorder shall always read the rod after the rodman, make the necessary calculations and compare the results with the rodman. If the results differ, each shall again read the rod before comparing results, and if the readings of the rod differ another setting of the target shall be made by the instrument man.

(3) Work must not be attempted during high wind nor when the air is "boiling" badly. During very hot weather an effort should be made to begin work very early and remain out late, rather than to work during midday.

(4) Foresights and backsights should be of equal length, and no sights over 300 ft. shall be taken unless unavoidable circumstances necessitate the same, as in the case of crossing rivers or deep ravines. In such cases extra precautions must be taken and the average of repeated readings at changed positions of rod and instrument taken.

(5) If it be impracticable to take equal fore and back sights, as soon as the steep slope or river crossing is passed, enough unequal sights shall be taken to make each set balance.

(6) Distances along railroads may be taken by counting rails; at other times stadia or pacing may be used.

(7) The instrument must always be leveled exactly before setting the target. After setting it and before giving the signal "all right," the level bubble must be examined. One rod, No. 1 or No. 2, should always be read first, so that one rod is used as foresight first at one set-up and as backsight first at the next set-up. The bubble tender shall always stand on the same side of the level tube when the reading is made, moving around the tripod as the level tube is reversed.

(8) The level must be examined daily or oftener, if necessary, for adjustment, the especially important adjustments being the line of collimation and the level bubble.

(9) The steel pegs, as furnished, must be used as turning points in all cases. These shall be firmly driven in the ground, and the backsight peg shall not be removed until the foresight reading is completed and the recorder and rodman have compared results on the backsight.

(10) Plumbing levels must always be used and kept in adjustment.

(11) Bench marks or turning points left at the termination of work at night, or for rain or other causes, must be selected with great care and located in such a manner that there will be no danger of their being disturbed or tampered with in order that the rod may again be held on the exact spot.

(12) Permanent bench marks shall be clearly described, not only with reference to the nearest base line station, but also to existing and easily identified features of the ground. A sketch shall be made showing the location of the bench mark and the reference marks referred to.

(13) All circuit closures or checks by duplicate lines shall be distinctly noted and a reference made to the check levels.

Duplicate lines of levels shall be run forward and backward and the error of closure of the two runnings shall fall within .020 ft.* $\sqrt{}$ distance in miles between benches or the lines shall be re-run. Bench marks shall be established at intervals of one-half to one mile.

On the Champlain Canal a single line shall be run from the Erie Canal to Whitehall. The error of closure with the U. S. D. W. shall fall within .050 ft. $\sqrt{}$ distance in miles between the benches, or the lines shall be re-run in the opposite direction.

The number of men in each party shall consist of five—an instrument man, a recorder, two rodmen and an umbrella man. The instrument must always be shaded from the sun, both during the set-ups and in moving from point to point.

PROCEDURE OF WORK.

Starting from a bench or turning point, the instrument man paced along the towpath from 200 to 250 ft. and set

*After the levels had been run from Albany to Herkimer, the results were so good that the limit of error was reduced to .016 $\sqrt{}$ distance in miles between benches.

e level, protecting it by the umbrella and wind shield sion required.

man No. 1 remained at the bench and rodman No. 2 g at the same bench, paced to and beyond the in- nt till he reached a point as many paces beyond strument as the instrument was from rod No. 1, at point he drove the steel pin.

g carefully leveled the instrument, the leveler set rget on rod No. 1 as a backsight, and then, avoid- th haste and delay, turned the telescope to rod No. 2 t the target as a foresight. The bubble tender kept bble constantly in the middle of the tube by slight e of the fingers on the leveling plate of the in- ent. To balance errors due to defective vision of the tender or differences in the light on the bubble, ubble tender moved around the tripod when the pe was turned.

recorder remained with rodman No. 1 until both he he rodman had read, recorded and checked the rod g, when he walked rapidly to pin No. 2, checking aced distances on the way. The recorder than read, ded and checked the reading of target No. 2 and ded "all right" to the instrument man, who repeated ignal to rodman No. 1, when they both moved for- ward. Rodman No. 1, going to rod No. 2, read, recorded, puted and compared results with rodman No. 2 and the recorder, the leveler having at the same time paced up to point No. 2 to check the pacing and then paced past point No. 2 the proper distance and set up the instrument. Rodman No. 1 paced up to the instrument from point No. 2 and then an equal distance beyond it and drove steel pin and set target. Thus this alternation occurred: First set-up, rod No. 1 on backsight is set first and rod No. 2 on foresight is set last; on second set-up rod No. 1 on foresight is set first and rod No. 2 on backsight is set last.

The datum of the surveys of 1900 and 1901 had to be adjusted to the fact that nearly every former survey gave a different value for the difference in level between the sea level at Governor's Island and the elevation of the "Greenbush bench," established by the U. S. Coast and Geodetic Survey in 1857 at the old Grist Mill at Greenbush, opposite Albany. The U. S. Deep Waterways Commission collated these differences, and Mr. Bond has added data bringing the record up to date as follows:

Elevations of Greenbush Bench.

Date.	Authority.	Location of gage.	Elevation, ft.
1857-8	J. B. Vose, U. S. Coast Survey	Governor's Isl.	15.37
1875	St. J. B. Williard, U. S. Engrs.		15.37 ± 0.50
1877	O. H. Tittman, Coast & Geodetic Survey	Governor's Isl.	14.728
1889	Deduced from West Sh. R. R. survey	Weehawken.	16.01
1894	Coast survey (mean of following two lines)		13.64
1893-5	Coast sur. from Boston.	Boston.	14.07
1893-5	Coast survey from Sandy Hook	Sandy Hook.	13.22
1898-9	Coast survey, Appendix No. 8, p. 414	Adjusted net.	13.732
1898-9	Coast survey, Appendix No. 8, p. 540	Adjusted net.	13.577

The value of 14.73 ft. above mean tide at Governor's Island has been adopted by the State Engineer as the elevation of the Greenbush bench, for the following reasons: The U. S. lake surveys, the elevation of Lake Champlain as fixed by the U. S. Coast and Geodetic Survey, U. S. Deep Waterway surveys, and the 1900 Barge Canal surveys are all based upon this elevation; and any future improvement in water transport between Lake Erie and the Hudson will probable use these surveys as a base. When future determinations fix the actual value of this bench, the elevations given to this survey can be readily reduced. The report gives the tabulated results of the levels between Greenbush and Buffalo. In a comparison of final results the elevation on the bench-mark on the light-house at Buffalo, referred to Greenbush "14.73," is fixed at 591.21 by the N. Y. Surveys of 1900-01. As corrected by a combination of the surveys of the Deep Waterway and Lake Survey, the elevation of this bench is 590.95; the N. Y. Canal Survey of 1876 made it 590.57, and the U. S. Geological Survey, 591.00.

In connection with the topographic survey of the State of New York, in co-operation with the U. S. Geological Survey, the report states that 147 separate atlas sheets have been surveyed and mapped, covering 28,105 sq. miles, or over 59% of the total area of the State. Of these, 106 have been engraved and published, representing the topography of 19,048 sq. miles. The average cost of mapping this area has been about $12.41 per sq. mile, of which sum the State has expended $148,500 out of a total outlay of $348,936, or $5.28 per sq. mile. Of the unmapped 21,085 sq. miles, 13,500 sq. miles are now controlled by primary triangulation and precise leveling, and are ready for the final topographic mapping.

THE EARTHQUAKE IN THE TRANSCAUCASUS.

In our issue of Feb. 20, 1902, we noted very briefly a severe earthquake which centered at the city of Shemakha, in Russian Transcaucasia. The losses of life and property in the catastrophe were enormous. The number of killed is estimated variously at from 3,000 to 5,000. In a

Fig. 1. View in Wrecked Street of Shemakha After the Earthquake of Feb. 13, 1902.

recent issue of the "Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereins" there appear two photographs taken in the affected district, which were sent to that paper by an eyewitness. We reproduce the views herewith, and abstract our contemporary's account, as follows:

The earthquake began shortly after noon on Feb. 13. Soon a number of terrific horizontal shocks were felt, throwing down houses and working destruction and death. In some places the ground seemed to rise in great waves, and large fissures opened. The city was enveloped in a vast cloud of dust, which added to the confusion and horror. Few houses in the city of Shemakha remained standing. Fig. 1 shows a view in one of the streets of the city. The houses were built mostly of a soft calcareous rock, in a rather unsubstantial manner, and had no strength to resist the violent horizontal vibrations. A number of wooden houses and a wooden church were comparatively little injured.

Coincident with these earth vibrations, a volcano of mud broke out at Madrasi, about 20 miles southwest of Shemakha. The appearance of the cone after the eruption is shown in the view Fig. 2.

Shemakha was in former centuries an important and flourishing city. It lay on the highway to India, and thus was a great trading center. In the 18th century it was destroyed by Nadir Shah in a religious war, but after some years it was rebuilt on the same site. A violent earthquake in 1859 caused the transfer of the Russian governor's residence to Baku, on the Caspian Sea. In 1872 it was visited by another earthquake, which was much more disastrous than that of 1859, and which destroyed the greater part of the city. In recent years the city has had a population of about 20,000.

GRASSES AS SAND AND SOIL BINDERS.

In a letter published in this issue, a correspondent asks for information upon a subject of much interest to engineers, but upon which there is little to be found in engineering literature. For this reason we have prepared the following abstract of a paper published in 1895 by Prof. F. Lamson-Scribner, then Agrostologist to the U. S. Department of Agriculture. It presents the best available data upon the protection of sandy coasts from the destructive agencies of waves and wind.

By sand-binding grasses, with stems bending to the elements and deep, wide roots gathering the sand together in a network of strong fibers, Holland largely holds the land she has wrested from the North Sea; and here and in other countries laws have been enacted for the careful preservation of the grasses that are best adapted to this purpose.

All sand or soil-binding grasses have strong, creeping roots—or really modified underground stems. The distinction between sand-binders and soil-binders is that the latter, growing on loamy or clayey soil, form a compact turf, and with these may be classed the mud-binders, or the grasses of the bogs and muddy banks of rivers. Of the true sand-binders there are two forms—first, the larger and coarser sorts; those which are exposed to the most severe action of the waves and wind, and have their so-called roots deeply buried in the sand. These send up large leaf and flower-bearing branches and grow in scattered tufts. The second form of sand-binder has prostrate stems that creep over the surface of the sand and send out at frequent intervals long fibrous roots. The grasses of the first kind have little or no value as forage; those of the second class form close mats over the ground, and usually possess considerable value for grazing.

As to the distribution of these grasses upon our own coasts, to the far north—on the Atlantic coast—sea lyme grass is the most common sand-binder. South of Maine, "marram" grass is the leading species; this is replaced, south of Maryland, by "bitter panic" grass, which extends to Florida and around some part of the Gulf coast. Other southern grasses are the "St. Augustine" and the "creeping panic" grasses. Inland, and away from the influence of salt water, the most important sand-binders are the long-leafed sand grass and Redfield's grass; the alkali grass, fine-top salt grass, and grama grasses are useful for this purpose in the southwest of the United States.

The propagation of sand-binding grass can be effected by seed—where this seed can be procured; but the better way in most cases is to collect and transplant cuttings of the creeping rhizomes. A comparatively small amount will serve to cover a considerable area, for they may be cut into single joints—and every joint will establish a new plant. The trouble is that the propagation of grasses of this kind has received very little attention up to the present time, and we are lacking in actual experience as to best methods and results.

For a seacoast sand-binder, Marram Grass, or Sand Reed, is the best known and one of the most important. The stout, long-leafed, coarse stems spring from widely creeping rootstocks, and usually grow in tufts 2 to 4 ft. high. As the sand

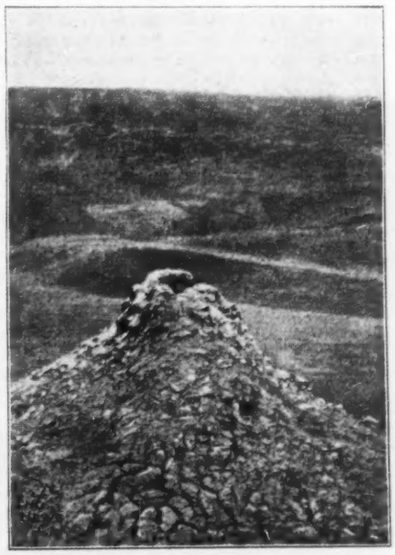


Fig. 2. Mud Volcano at Madrasi, Thrown Up at Time of Shemakha Earthquake.

drifts in around these plants new branches are formed in the lower leaf axils, and the plant spreads. This grass is common along the coast of Northern and Western Europe, and on the Atlantic coast of the United States from Virginia northward. It also grows abundantly along the shores of the Great Lakes. For sand-binding purposes it has no superior. This Marram grass has been introduced along the Pacific Coast for bind-

ing sand dunes near San Francisco; though, strange to say, the seed was obtained from Australia. It will grow well on sandy clay soil, far removed from the coast, and is thus used for railway embankment protection. While it may be raised from seed, it grows more rapidly and certainly by root-cuttings. These cuttings are planted in rows 6 ft. apart and 2 ft. distant in the rows; buried from 12 to 15 ins. in the sand. The seed is occasionally to be found with leading seedmen.

Fig. 1. Marram Grass.
(Ammophila arenaria.)

Fig. 2. Upright Sea Lyme Grass.
(Elymus arenarius.)

The upright Sea Lyme Grass is hardly less important than the Marram. This grass has stout, smooth culms, 3 to 6 ft. high, and long, sharp-pointed, rigid leaves. It is common on the coasts of North Europe, Great Britain, and on our western coast as far south as Oregon. A closely related species occurs on the Atlantic Coast from Maine northward and on the shores of Lake Superior. Lyme grass is often grown with the Marram grass; the Lyme grass securing the bottom of the hills of sand formed about the Marram grass. For binding loose sand, Lyme grass has been cultivated for over one hundred years in Europe.

Bitter Panic Grass grows on our Atlantic coast south of the range of Marram grass. On the Carolina coast it is 2 to 5 ft. high, has large and many-flowered panicles, and closely resembles Switch grass. The stems are coarse and hard, sometimes one-half inch in diameter at the base; and the leaves are firm in texture and very bitter to the taste. It has strong, spreading root-stocks.

Among other grasses suitable for sand-binders are: Switch grass, easily propagated by seed or cuttings; Water Oats, or Beech Grass, which grows from Virginia to Florida and is a first-class sand-binder for Southern and Gulf coasts. In California, the Beech Grass, or Uniola condensata, is similar in habit and closely allied. The Uniola latifolia is common in the Middle and Southern States away from the seashore; and it is highly ornamental as well as useful in binding the banks of streams or embankments not too dry.

The Rolling Spinifex is a notable sand-binder on the sandy coasts of Australia, Tasmania and New Zealand. It has hard, creeping stems which root at every joint. The heads are driven over the sands by the winds and drop their seeds as they roll. It would be valuable on our own Southern coast. The St. Augustine Grass is the Buffalo Grass of New South Wales and the Pimento Grass of Jamaica. It grows upon every variety of soil, from sand dunes to heavy clay. The flattened stems send out roots at every joint. It is best propagated by settings and spreads quickly. Creeping Panic grass belongs to this same class of sand-binders, and is widely distributed along the Gulf coast; it is as effective as the more deeply rooted Panic grass in protecting sand from the wind.

The principal inland sand-binders, ranking with Marram and Sea Lyme grass, are the long-leafed Sand Grass and Redfield's grass. The first grows on the borders of Lake Michigan and extends from Illinois westward to the Rocky Mountains and south to Kansas. It has far-reaching scaly root-stocks; stout stems, 2 to 6 ft. high, and numerous rather rigid leaves, 1 to 3 ft. long. Redfield's grass is rather more limited to the sandy regions of the West. It is the characteristic grass of the sand hills of central Nebraska. Its hard, smooth, long-leafed stems grow in tufts 2 to 4 ft. high; and the rootstocks are strong and persistent. This grass is recommended as a sand-binder.

Fig. 3. Rolling Spinifex.
(Spinifex hirsutus.)

For holding embankments where a firm turf is required, Couch, or Witch grass does excellently in the Northern and Middle States. It presents a number of forms, and all are good hay grasses, but they are objectionable in fallow lands owing to the widely spreading and very persistent jointed rootstocks. Couch grass makes a very tough sod, and is particularly valuable in binding railway embankments, banks of canals, ditches, etc.

Hungarian Brome Grass is a good former and may be used in much the same way as Couch Grass; though the creeping rhizomes are not so strong as the latter. In the South States, where Couch Grass does not succeed well, Johnson or the finer Bermuda grasses may be substituted. The Johnson Grass produces a great mass of widely creeping, strong rhizomes; and when it once fills the ground it is almost impossible to eradicate it. Bermuda Grass grows more upon the surface; and upon a light sandy soil it succeeds better than the Johnson Grass. Bermuda Grass is of great value in holding levees of sand or loose soil; and it is at the same time one of the best pasture grasses in the South. If the land is moist and the soil is somewhat clayey, Knot Grass may be substituted for Bermuda; and this Knot Grass is especially well adapted to cover silt or bare slopes on the banks of ponds or rivers. Moderate submersion does not injure it.

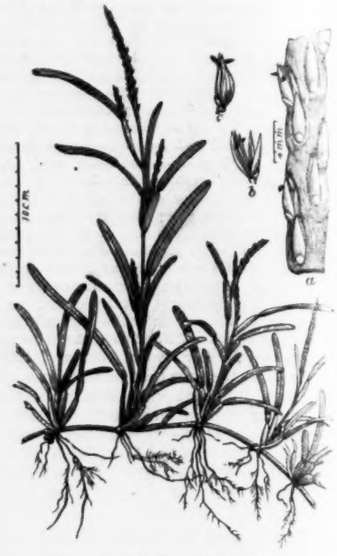


Fig. 4. St. Augustine Grass.
(Stenotaphrum Americanum.)

Fig. 5. Louisiana Grass.
(Paspalum compressum.)

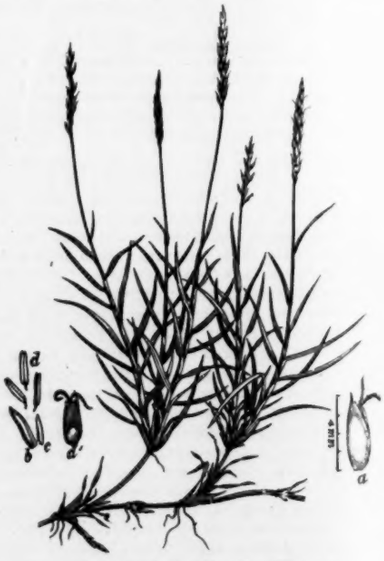


Fig. 6. Coast Couch Grass.
(Zoysia pungens.)

The use of beach grass for a sand binder is referred to in the 1901 report of the Massachu-

...Board of Harbor and Land Commissioners. This was done in connection with the construction of a road across the Province Lands by Mr. James A... Nail, Superintendent, Provincetown, Mass. The two-mile road extends to the outer beach, and it was necessary to check the drifting sand and reclaim land. This was done by transplanting beach grass for a sand binder and planting trees and shrubs, principally pines and bayberry (Myrica cerifera). The beach grass was transplanted from the middle of May till June 5, and again in September, October and November. A total area of about 20 acres was covered in this way. Owing to the excellent results obtained the bayberry was introduced simultaneously with the grass. Since 1895, 170 acres of the exposed sand slopes have been covered with the grass. It has stopped the movement of the sand and successfully withstands the high winds. The beach grass mentioned in this report, though unnamed botanically, appears to be identical with the marram grass referred to in the article above.

PLANS FOR THE PROTECTION OF GALVESTON FROM FLOODS.

In November last, the Board of Commissioners of the City of Galveston appointed Messrs. Alfred Noble and H. C. Ripley and Gen. Henry M. Robert, to report a plan for the protection of Galveston from overflows by Gulf storms. On Jan. 25 these engineers presented a report which was printed in full in the Galveston "News" of Jan. 26. The principal features of the plan adopted were briefly summarized on p. 77 of our issue of Jan. 30. In view of the importance of the work, however, and of the novelty of the engineering problems presented, we have deemed it worth while to present below a fuller abstract of the engineers' report, together with drawings furnished to us by Mr. Ripley:

The city of Galveston is located on the eastern end of Galveston Island. The original elevation of the ground was in many places but little above ordinary high tide of the Gulf, and at extraordinarily high tides the water came into the streets in many places.

This condition was ameliorated somewhat by filling up in low places with material at first hauled in from the sand hills, which had formed along the Gulf beach, and afterward it was brought from the island at a point several miles west of the city, and from the mainland by rail and later by dredging from the bay.

In 1875, or thereabouts, a general system of levels was taken throughout the city and grades for the streets were established. The elevation of the natural surface of the ground in the streets is nowhere greater than 8.9 ft., and the average elevation from 6th to 39th St. is about 5.8 ft. The average elevation of the ground west of 39th St. is much less and is approximately 3.7 ft.

THE RECORD OF STORM OVERFLOWS IN GALVESTON.

The higher portions of the city are generally above overflows during storms, and it is only during phenomenal storms that the city is completely or to a great extent submerged.

Such storms occurred within the memory of those now living, namely, in 1834, 1837, 1847, 1854, 1867, 1875, 1886 and 1900. The actual height of the water in these earlier storms is largely a matter of conjecture. The fact of the water coming upon the island, however, has been indelibly impressed upon the minds of all old citizens. In 1834 the island is believed to have been entirely submerged. In 1837 a vessel drawing possibly as much as 10 ft. of water was landed on Avenue J, between 40th and 43d Sts., where the elevation of the ground is now about 5.5 ft.

In 1900 the water reached a height exceeding by far any previous record at Galveston.

The greatest height of water was at 8th St. and Avenue B, with an elevation of 15.7 ft., and the least height was at the Southern Pacific Wharf, with an elevation of 10 ft. The one is at the east end, outside of the line of debris, with low ground towards the Gulf, and probably represents the greatest height of the water at any point in the city. The other was far enough removed from the obstructing influence of the buildings to the water's flow to represent the general level of the bay along the city front at that point.

Aside from the buildings which failed to withstand the violence of the wind, which reached a velocity of 100 miles per hour before the recording apparatus was blown away and were thus damaged or entirely wrecked in all parts of the city, the greatest destruction was caused by currents and wave action.

The damage due to these causes was greatly aggravated in the first instance by the wreckage in the form of heavy timbers from the railroad trestle at the jetty and from the street car and railroad trestles in the city. These heavy timbers, with steel rails attached, battered down many buildings and the increasing wreckage added to the elements of destruction. In some portions on the south side, especially west of 25th St., the testimony seems to indicate that the appearance of destructive wave action was sudden, after which the destruction of buildings was very rapid and complete. The accumulation of debris, however, finally became a barrier, behind which no destructive wave action was felt, and the complete demolition of buildings in the area thus protected was averted. Except in rare instances, the line of debris marks the limit of total destruction.

The greatest loss of life, as might be expected, was also embraced in the area of total destruction of buildings.

As the occurrence of the destructive overflows are due to cyclonic disturbances originating in the West Indies, it will be of interest to inquire as to the frequency of these phenomena which may cause apprehension of danger or come near enough to this locality to cause overflows and other destructive effects.

The United States Weather Bureau has made a study of these phenomena and has traced and recorded their paths.

From the publications issued upon this subject, we learn that between 1873 and 1900 82 hurricanes have occurred, of which 38 have come into the Gulf. This is within a period of 28 years, and shows that the frequency of these cyclones which enter the Gulf have averaged 1.4 per year. Of these storms 3 have occurred in June, 3 in July, 11 in August, 12 in September and 9 in October. Of these 38, 11 have reached the Texas coast, which gives one in 3½ years. We may, therefore, expect once in 3½ years the appearance of cyclones which will cause serious apprehension and possible danger at some portion of the Texas coast.

Protection from storms is not only required for the preservation of life and property, but also, in hardly less degree, to give confidence to the people of Galveston and to others who may be drawn here by business interests, in the absolute safety of the city against the recurrence of such catastrophes as the one of 1900.

Excepting in the storm of 1900, the highest level reached by the water, so far as the board has any positive information, was in the storm of 1875, when it was 9.5 ft. above mean low water at 10th St. and Avenue L, quite near the Gulf shore. On the Bay side the highest water in this storm was 3 ft. lower, or 6.5 ft. above mean low water, and intermediate high water marks are in harmony with this indicated slope from the Gulf. The records of the storms of 1867 and 1886 are not so complete as those of 1875, but the water appears to have reached nearly, if not quite, the same height.

If no worse storms were to be feared than those that occurred in the 50 years preceding the 1900 storm, the city of Galveston could be placed above the reach of the highest water by raising the grade of Avenue A to 7 ft., and sloping upwards to 10 ft. at the beach, and protecting the beach side by a sea wall. But the storm of 1900 was about 6 ft. higher than any of the previous storms at Galveston, of which any positive data have been obtained, and while it is not probable that such a storm will soon again strike Galveston, yet such a thing is possible and should be provided against, if within the means of the city.

Fig. 7. Long-Leafed Sand Grass.
(Calamovilfa longifolia.)

Fig. 8. Redfield's Grass.
(Redfieldia flexuosa.)

Fig. 9. Bermuda Grass.
(Cynodon Dactylon.)

Fig. 10. Fresh-water Cord Grass.
(Spartina Cynosuroides.)

The board is of opinion that it is practicable, at an expense not large, compared with the results obtained, to place Galveston entirely out of the reach of any storms like those from which she suffered previous to 1900, of which we have positive data, and at the same time make the city safe from any serious damage from water in a storm like the one of 1900.

THE PROJECT FOR PROTECTION OF THE CITY.

In preparing a project for the protection of Galveston from the waters of the Gulf in storms, the board has kept the following objects in view:

(1) To protect the city from the force of the waves and the currents in the severest storms known to occur in the Gulf.

(2) To protect the city entirely from the water of the Bay and the Gulf in all such storms as occurred during the 50 years preceding 1900.

(3) To prevent the water in the severest storms, such as the one in 1900, from ever reaching a depth in the city dangerous to life or property.

(4) While providing for the above, to arrange the filling so as to secure sufficient elevation for drainage and sewerage.

To accomplish these objects the board would propose, in brief, the building of a solid concrete wall, over three miles long, connecting with the south jetty near 8th

St., thence to 6th and D, thence across the island and down the beach as far as 39th St. The top of this wall to be 17 ft. above mean low water, or 1.3 ft. higher than the highest point reached by the water in the storm of 1900.

(2) The raising of the city grade to 8 ft. at Avenue A, 10 ft. at Broadway, 12 ft. at Avenue P, and continuing this slope to the sea wall. This corresponds to a rise of 1 ft. in 1,500 ft. from the Bay toward the Gulf.

(3) The making of an embankment on top of this fill adjacent to the wall, and rising to a height of 18 ft. above lower water at a distance of 200 ft. from the wall, and thence sloping down on a grade of 1 in 50 to the surface of the fill.

The raising of the city grade is necessary to get the streets and lots sufficiently high for safety to life and property in severe storms. The sea wall is necessary to protect this filling from the force of the waves.

With this project carried out, the portion of the city so protected would not be exposed to any danger from the waters of the Gulf, though in a storm like that of 1900 the water in the Bay might be 2 ft. higher than the grade at Avenue A, but would never reach far beyond Broadway, though doubtless some of the Gulf water would slop over the sea wall and embankment from wave action and run down the slope in a thin sheet. This could

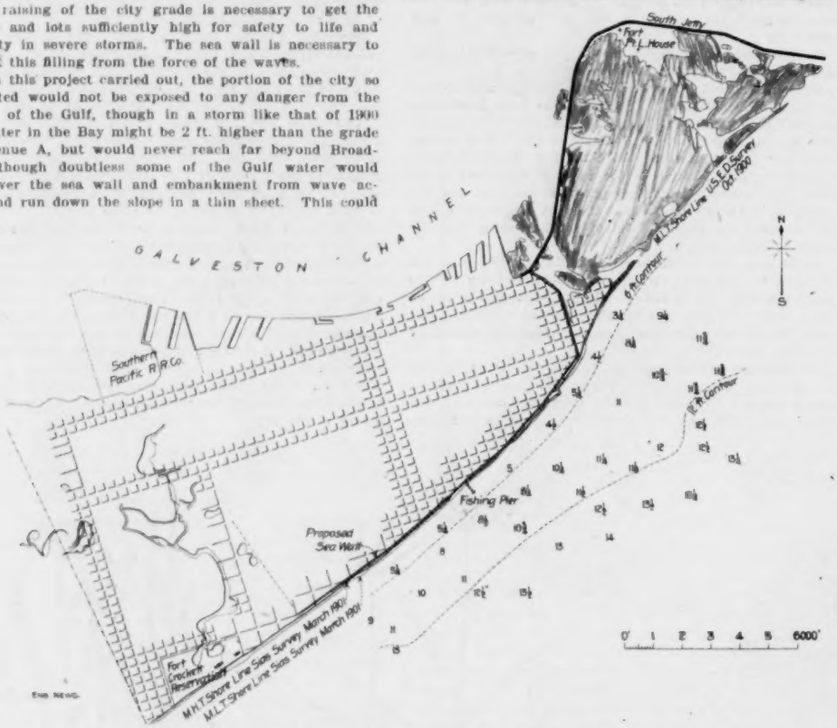


FIG. 1. MAP OF THE CITY OF GALVESTON, SHOWING PROPOSED SEA WALL FOR FLOOD PROTECTION.

continue only for a short time, while the water is at its maximum height.

The sea face of the concrete sea wall is to be curved so that its upper portion will be vertical. This will give the wave an upward direction and prevent to a great extent its running up and over the embankment behind the wall. The wall will be founded on piles and protected from undermining by sheet piling and also riprap. It will be located back from the high water line where the ground is about 3 ft. above mean low water. Its width at the bottom (1 ft. above mean low water) will be 16 ft. and at the top (17 ft. above mean low water) its width will be 5 ft.

The height of the filling behind the sea wall will vary with its distance from Broadway, where the grade will be 10 ft. above low mean water.

The top of the sea wall along the beach between 6th and 39th Sts. would be on the average about 4 ft. above the fill, if no embankment were added. In the case of a very severe storm, where waves might go over the wall, the effect of the overfall in cutting away the sand behind the wall would be bad. The wall would very much obstruct the view of the Gulf. Both of these are avoidable by placing an embankment as previously described behind the wall.

The top of this embankment for 35 ft. from the sea wall would be protected by a brick pavement, and 60 ft. further by soil and Bermuda grass. The brick pavement, which would consist of vitrified brick laid on edge, would provide a driveway 30 ft. wide and a sidewalk 5 ft. wide, which, added to the available part of the top of the wall, after a strong iron railing is placed on it, would give an available sidewalk of 9 ft.

A levee to exclude the water from the west end of the city will extend from 39th St. and Avenue T½ to Broadway and 45th St., skirting the eastern border of the marsh. Thence it should be eventually extended as far as Avenue A on such a slope as to coincide with the grade of that avenue when it reaches its northern end.

The width of the levee is made 300 ft., with side slopes of 1 ft. in 25 ft. It is assumed on account of its elevation that it will be utilized for residence property and be thus protected with buildings and grass. Some of it may have to be protected by soil and grass by the city. Its top is above the highest water marks of the 1900 storm.

It will be seen, then, that the proposed plan surrounds the city on three sides with a wall and levee that rise higher than the highest water in the storm of 1900, leaving only the Bay side open to the water, and there the city is raised higher than the waters of the Bay have ever been recorded except in the 1900 storm. And it is believed that if this protection had existed in 1900 the water in the city on the Bay front would not have been deeper than 3 ft. in the eastern portion, diminishing, say, to 1 ft. in the western portion.

If a sea wall like the one proposed had existed at the time of the storm of 1900, even without any raising of the city grade, the city would have been protected on the east and south for over three miles with a solid concrete breakwater, 17 ft. high above mean low water. As this breakwater would have been higher than the waters of the Gulf, it would naturally have reduced the height of the water in the city behind it, besides to a great extent destroying the force of the waves.

The existence of the breakwater, even without any

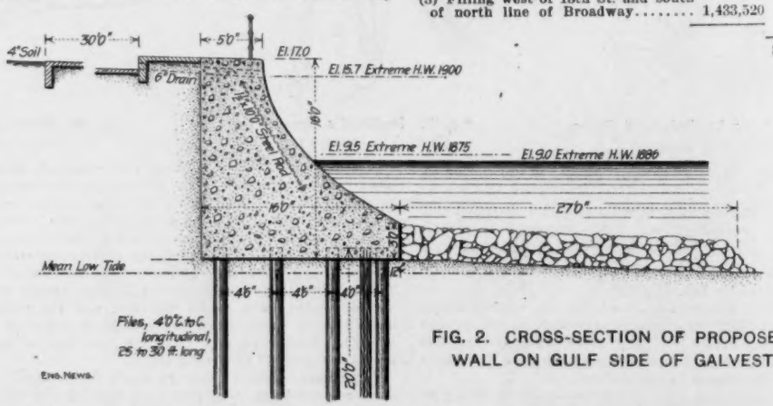


FIG. 2. CROSS-SECTION OF PROPOSED SEA WALL ON GULF SIDE OF GALVESTON.

filling, at the time of the storm of 1900 would undoubtedly have been a great benefit.

The filling proposed to be made over the city, together with the embankment immediately behind the sea wall, is hardly less indispensable than the sea wall itself. It places the entire city area above the height of ordinary floods. The flood of 1875 would have been entirely excluded with a margin of 1.5 ft. The flood of 1900 would have submerged the Bay front to a depth of 2 or 3 ft., but would not have extended far south of Broadway. Should such a storm recur, the greater part of the area south of Broadway would remain above water.

The filling to the grades proposed will afford another advantage of almost equal importance [illegible] facility given for an adequate sewerage system.

SEWERAGE AND DRAINAGE.

The problem of getting satisfactory sewera[illegible] drainage for the city has always been a serious [illegible] on account of the flatness and low elevation of th[illegible] nd, and also on account of high tides which obstru[illegible] outflow of the sewers and storm drains. This obstr[illegible] to the outfall of the storm drains usually occurs [illegible] time when the greatest rainfall is experienced, a[illegible] ther aggravating the situation.

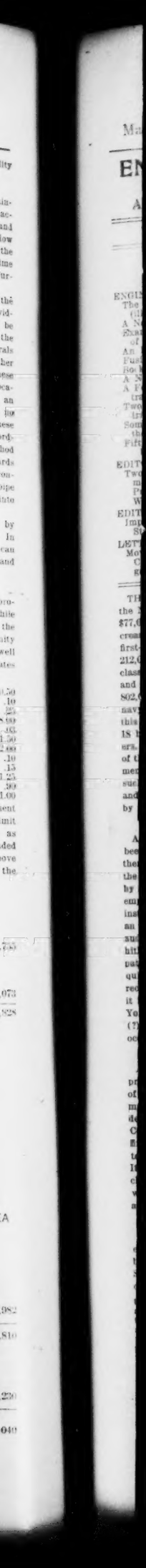
In considering the question of raising the [illegible] of the city, the board has kept in view the necessit[illegible] providing for ample grades for main sewers, wh[illegible] all be self-cleansing and shall extend from the Gulf [illegible] to the Bay side of the city, together with the neces[illegible] laterals for serving the territory for at least two block[illegible] either side of each main sewer. The discharge [illegible] these sewers may be collected in receptacles at su[illegible] locations near the north side of the city and pum[illegible] to an outfall by forcing it through an iron pipe, [illegible] at no great depth below the surface of the ground. [illegible] these receptacles may be emptied by compressed air [illegible] accordance with the Shone system, or by any oth[illegible] method which may seem to be the most desirable [illegible] regards economy and utility. Such a plan would permit the construction of storm drains underneath the disch[illegible]e pipe for sewerage and the sewer laterals, and extending into the Bay at the wharf front for an outfall.

Very exceptional rains cannot be fully provided for by underground drains without an unwarranted expense. In such cases the surface water beyond what the drains can accommodate will find its way through the streets and into the Bay.

UNIT PRICES AND ESTIMATES.

The unit prices used in estimating the cost of the proposed work are the result of careful investigation. While they are probably close figures, they are based on the actual cost of labor and materials used in this vicinity and on information as to local conditions, from those well qualified to give it, and the board believes the estimates entirely safe. The unit prices are as follows:

Excavation for sea wall, per lin. ft. of wall	$0.50
Piles driven, per lin. ft. of pile	.10
Sheet piles driven, per lin. ft. of pile	.25
Concrete, per cu. yd	8.00
Steel rods and cast-iron washers, per lb	.03
Hand rail, per lin. ft. of wall	1.50
Riprap, in place, per ton	2.00
Filling, south of Broadway, per cu. yd	.10
Filling, north of Broadway, per cu. yd	.15
Brick paving, per sq. yd	1.25
Brick curb, per lin. ft.	.30
Soil and Bermuda grass, 60 ft. wide, per lin. ft.	1.00

The filling in these estimates includes the embankment behind the sea wall and the levee on the western limit of the area south of Broadway. The estimates are as follows. The form of breakwater or sea wall recommended by the board is shown in Fig. 2. At the unit prices above named, its cost will be $66.50 per lin. ft., including the hand rail and riprap protection.

(1) Breakwater or sea wall; the total length is 17,700 lin. ft., at $66.50	$1,177,050	
Add 10% for engineering and contingencies	117,705	
Total estimated cost		$1,294,755
(2) Filling east of west line of 13th St. and south of Market St.	$206,553	
(3) Filling west of 13th St. and south of north line of Broadway	1,433,520	
		1,640,073
		$2,934,828
(4) Filling east of west line of 13th St. and north of south line of Market St.	31,082	
		31,982
		$2,966,810
(5) Filling streets, avenues and alleys west of 13th St. and north of Broadway	229,185	
(6) Filling lots west of 13th St. and north of Broadway	309,045	
		538,230
Total cost of entire project recommended by the board		$3,505,040